WORLD FOOD PROBLEM

Span

VOL. 4 No. 1 1961

Span

VOL. 4. NO. 1. 1961

Span *is published quarterly by Shell International Chemical Company Limited, St. Helen's Court, Great St. Helen's, London, E.C.3, and is distributed by Shell Companies throughout the world.*

The Editor invites readers to submit contributions (if possible typed, double spacing) for publication in Span. *Authors are free to state their own views and the opinions expressed in articles are not necessarily shared by the Editor.*

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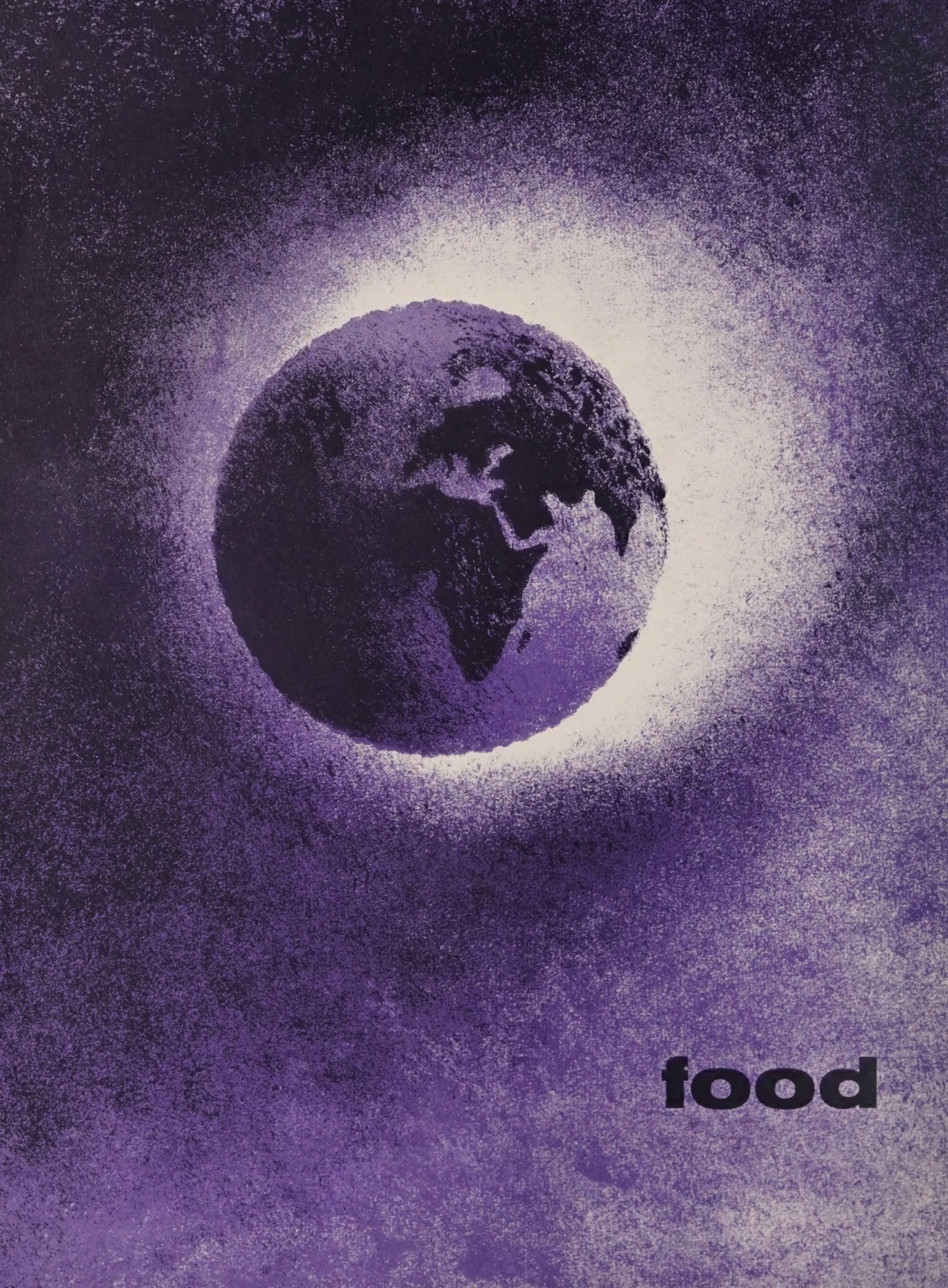

food

THE problem of satisfying hunger throughout the world has recently been described as the biggest technical challenge of our times. That this is so is shown by a very brief summary of certain basic facts. First, it is variously estimated that one third to more than one half of the people in the world today go hungry. Secondly, the world population, at present just short of 3,000 million, is, according to United Nations figures, growing at the rate of 1.6 per cent. per annum, and will have doubled by AD2000. (It is, perhaps, something of a paradox that the medical advances which, by bringing malaria and other killing diseases under control, have played so big a part in increasing the population by reducing the death rate, have brought in their wake the problem of feeding those whose lives have been saved.)

Thirdly, although during the past few years food production has been increasing annually by about 2 per cent., much of this increase is in the advanced countries, whereas the extra food is needed in the emerging countries where the biggest population growth is occurring. (By AD2000, it is thought, population will increase by two-and-a-half times in Africa, nearly three times in Asia, and over three-and-a-half times in Latin America.)

The problem of ensuring that in the years to come millions do not die of starvation, or at the very least suffer from severe malnutrition, needs to be viewed in two lights: can and should the birth rate be controlled; and how is enough food to be produced, and produced where it is needed, to feed the increasing population.

This issue of *Span* is largely devoted to a consideration of the second part of the problem, that of producing more food; but that does not mean that the question of population control can be entirely overlooked. For while increased food production will be of paramount importance, particularly in the short term, it seems inevitable that, as the size of the problem grows, more and more consideration will be given to birth control measures.

Population control is a problem on its own, but, as both L. D. STAMP and C. P. MCMEEKAN stress on other pages, there are many other sociological, psychological and political obstacles to be overcome before scientific and technical knowledge can be used to the full to enable more food to be produced in the under-developed countries.

Equally important is the question of economics: where there is money to pay for agricultural improvement, crop and livestock production soon increase. The money to bring about this improvement, and so to raise standards of living, comes from industrial development, which in turn must chiefly be brought about by the rich countries of the world capitalising the poor countries and providing markets for their goods.

The vexed question of the disposal of farm surpluses rests chiefly on the ability—or inability—of the poorer countries to pay. It is sometimes suggested that the 'haves' of the world ought to help the 'have nots' by giving away food or selling it very cheaply; but this must regrettably be seen as a counsel of perfection in an imperfect world, and can be regarded as unworkable on grounds of difficulties of distribution and of upsetting the ordinary markets.

Turning now to the technical aspects of increasing food production, two fundamental considerations present themselves: what foods are required and how they can be produced.

If the world population is going to reach 6,000 million by the turn of the century, it is estimated that present cereal production will need to be doubled and animal products increased by 200-300 per cent. Most malnutrition in the less developed countries is due to insufficient protein and, as is stressed in several of the articles that follow, particular importance must be attached to increasing protein production.

As to the methods of producing more food, increased production can, as N. W. PIRIE points out (p. 21), be based on three concepts: bringing more land into production; growing more on the land already being farmed; and protecting what has already been produced. The implementation of these basic means of increasing food production calls, of course, for the use of many different techniques, and it is the object of this issue of *Span* to draw attention to some of the most important.

It is against this background of a population rapidly outstripping its supply of food that the Food and Agriculture Organisation of the United Nations launched last year its five-year Freedom from Hunger Campaign, of which much has already been written. In effect an intensification of the work of FAO and of individual governments, the campaign is being fought on three main fronts: education, research, and action, and is aimed at improving understanding of the world food problem, studying methods by which the problem can be solved, and stimulating countries to take necessary action.

The urgency of the problem was emphasised at the 1960 meeting of the British Association for the Advancement of Science, when for the first time in its history it brought all its sections together for a day to discuss one overriding subject: world food and population. A committee of the Association has been formed to plan ways and means of focusing attention on the facts and implications of world food supplies and population.

On another page the Director General of FAO, Dr. SEN, appeals for wide support for the Freedom from Hunger Campaign: he should certainly receive it, for it is no overdramatisation to say that on the success or failure of the campaign will hang the fate of millions of people in the emerging countries of the world.

for thought

Towards freedom from hunger

by **B. R. Sen,** *Director-General, Food and Agriculture Organisation of the United Nations, Rome.*

FOOD SUPPLIES AND CONSUMPTION

During the last few years, there has been increasing awareness of the inadequacy of food supplies on a world-wide basis, and of the rapid growth of the world population which threatens to make food supply problems even more intense in the future. It is estimated that more than half of the world's population suffers from varying degrees of undernourishment and malnutrition. Further, malnutrition has been called 'hidden hunger', an expression which implies that people who have apparently enough to eat may nevertheless be unhealthy, become seriously ill, perhaps even die, because their diet does not provide all the elements needed for satisfactory growth and health.

The causes of under-nutrition and malnutrition are numerous, but the major causes are poverty and ignorance. In large areas of the under-developed parts of the world, millions of people live primarily on what they grow on their own land. Their food lacks many of those elements which constitute a balanced diet. A subsistence economy and malnutrition usually go hand in hand. Further, many people in the less developed parts of the world in city and country alike are too poor to be able to buy enough and the right kind of food.

In the longer term, the answer must be increasing agricultural productivity as one aspect of economic development, including bringing subsistence farmers more into the market economy, and raising the average income levels of those now living on the margin. In order that the rate of growth may be sustained in the agricultural field, it is essential that agricultural development forms an integral part of general economic and social development, including varying degrees of industrialisation, development of communications and social services, etc. But even while economic development is getting under way in less developed countries, it is possible to improve nutrition within existing income levels by spreading nutritional knowledge. In short, the economist, the agronomist and the nutritionist can work together to bring about improvements in nutritional standards in both the short and long terms.

It is well known that the process of improving agricultural production is slow and costly and highly dependent on factors difficult to control, including capital investment and technical knowledge. For example, the creation of educational facilities essential to the development of improved production practices also requires large investments in terms of capital and time. On the other hand, factors leading to the control of disease and mortality are likely to operate in a much shorter time. Sometimes the production of a new drug or pesticide can do much to eradicate an endemic disease and lower the mortality rate. This has been indeed the trend in many under-developed areas since the end of the Second World War.

Assessment of Food Supplies

One of the primary tasks in the work of FAO to help raise the levels of food consumption and nutrition, is the assessment of available food supplies and consumption at national, regional and global levels. Most of the information available in FAO is based on food balance sheets which give an estimate of *per caput* supplies available for human consumption and their calorie, protein and fat content. Information of this kind, however, is available for only about 40 countries, comprising less than half the population of the world. Moreover, the information available refers mainly to the more advanced countries. Information is generally lacking for a number of countries where the statistics are not well developed and where problems of malnutrition are likely to be serious. For many of these countries, however, there is some information based on data of food consumption surveys which not only show actual consumption of the families, but also the relation between levels of consumption and socio-economic factors.

By comparison with requirements based on the standards set up by FAO, it is possible to assess the deficiencies in diet in different regions and countries and in sections of the population within countries. Here again, the food balance sheets fail to tell the whole story. There are many countries where average calorie levels are not far below requirements. However, since the supplies are not equally distributed between the different socio-economic strata of the population, a large proportion receives much less than their share and, therefore, is seriously exposed to problems of under-nutrition. Furthermore, even when food supplies seem to be adequate from the quantitative point of view, the diets may still be deficient in quality. This is indicated in many population groups whose diets are

Children, in particular, in many parts of the world still suffer from severe malnutrition, much of which is caused by insufficient protein. (Photo: UNICEF)

based on one or two major foods such as cassava or grains. In such cases they lack protein of good quality and vitamins and minerals supplied by protective foods such as meat, milk, pulses, fruit and vegetables. Perhaps it would not be an exaggeration to say that the numbers affected by the 'hidden hunger' are today much larger than those affected by under-nutrition, and could be counted in some hundreds of millions.

The quality of the diets is generally indicated by the content in protein of good quality, especially of animal protein. Animal protein gives perhaps the simplest single indicator of quality, not because it is indispensable, but because foods of animal origin are also good sources of many other nutrients. The differences in the consumption of proteins between countries, as well as between socio-economic groups within the countries, are far greater than the differences in calorie intakes. For instance, the supplies of animal protein are about 8g. *per caput* per day in the Far East, 13g. in the Near East, around 40g. in Western Europe, and 65g. in North America. The scientific knowledge regarding assessment of protein requirements is not completely adequate, and there is no evidence of serious ill-effects of protein deficiency in adults. It is well known, however, that in the under-developed areas, many children suffer particularly from protein malnutrition during the first four years of life. In these areas, where the rate of population growth is faster, the expansion of production of protein-rich foods, especially those of animal origin,

often proves more difficult than for starchy foods. As a consequence, it may be some time before the general level of consumption of such foods increases appreciably.

Food Surpluses

A paradoxical situation has existed for the last decade or so. While many countries of the world are struggling to expand their production in line with increasing needs and to improve present low consumption levels, there are burdensome agricultural surpluses in some other countries. This being the case, the question arises: would it not be possible to use such surpluses to alleviate the situation of the worse-fed sectors of the population? Of course, much has been done in this direction, but the total volume of the world's surpluses of food is really quite small compared with the food requirements of the under-developed countries. FAO has suggested some ways and means of utilising food surpluses to help finance economic development, and to set up national food reserves to assist in ameliorating temporary imbalances in food supply and demand. Further, surpluses of dried skim milk, for instance, have been used to help countries to start programmes of supplementary feeding of vulnerable groups, and at the same time create economic and technical conditions which encourage the development of their own dairy industries.

INCREASING FOOD PRODUCTION

Having described briefly the situation regarding food supplies, it would be useful to look at the possibilities of increasing food production. We know that only about one-tenth of the land surface of the globe is at present cultivated. Meadows and pastures account for another 17 per cent.; forests for about 29 per cent., and almost half (43.5 per cent.) is waste land, or land that has been built upon and is, therefore, not usable at present for agricultural purposes. There is no doubt that wide areas of additional land could be brought under the plough, but only through the coordinated efforts of governments, involving heavy investments and, in some regions, a great deal of research. In the long run, the opportunities are very substantial indeed for the expansion of crop-bearing areas, including fuller use of presently cultivated land by irrigation to permit two or more crops a year.

Moreover, much of the equatorial region can be developed. Despite plentiful rainfall and temperatures that are highly favourable to plant growth, the continuously hot, continuously wet belt of tropical rain forest lying across the equator presents some conspicuous blanks in the world map of agriculture. There are great difficulties to overcome before the land can be made productive, but armed with the resources of modern science, man should be able to turn many little-exploited areas to good use, some for agricultural crops and some for tree cultivation which would give greater returns than the present low yielding forests.

In FAO we are concerned also with measures to increase yields from land already under cultivation, and here the technical possibilities are tremendous. Among the means of achieving increased production are: the better use and control of water; the building up of soil fertility; plant breeding and seed improvement; reducing losses caused by pests and diseases; better farming equipment and management and more efficient services to farmers; improved breeding and feeding of livestock. The greater part of FAO's programme aims at developing these and other measures.

If progress sometimes seems slow, we can derive encouragement from examples of yields which have already been achieved in certain parts of the world. We know that in Japan yields of rice are four times as great as in most other countries in Asia, a difference due not only to the large amounts of fertilisers used in Japan, but also to improved seed varieties, controlled irrigation and efficient cultural practices. According to FAO specialists, production could at least be doubled in many countries through these methods alone.

Preventing Waste

We know that large amounts of food are wasted, and that food and industrial crops are destroyed by pests and diseases in certain countries—sometimes as much as 25 per cent. This wastage is largely preventable by the control of pests and parasites and by food processing. While FAO places importance on the progress made in the field of modern methods, such as atomic irradiation, we are also developing work in the other methods such as refrigeration, canning, etc. In the developing countries, however, greater attention is being given to improving traditional methods of processing which do not require much material assistance, but rather demonstration through extension services of such methods as salting, drying, smoking, pickling, fermentation, etc. Projects of this type, mainly for processing at community and family level, have been developed in a few countries.

We know that the supply of livestock products could often be increased four or five times by the application of improved methods of animal husbandry. We know that in the sea and inland waters, there are large untapped sources of fish which the scientific development of fisheries would make available for human consumption, thereby increasing world supplies of good protein and helping to eliminate protein malnutrition. For instance, the production of fish in Africa went up from 380,000 tons in 1938 to 1,530,000 tons in 1956—an increase of about 400 per cent. If it is considered that the greater proportion of this increase has taken place in only three countries in which appropriate investments were made, the tremendous possibilities afforded by fisheries development in Africa can well be visualised.

Many of the obstacles to the rapid improvement of agricultural practices are to be found in factors outside the technological field. While greater human effort alone could make some contribution, this depends in part on dissemination of information and teaching of new methods through extension services which are frequently hindered by the lack of a sufficient number of technicians; it also depends in part on reorganisation of the social and

economic structure in which farmers work. But substantial increases in agricultural production require also substantial monetary investment, funds for which are usually scarce in less developed countries.

Food where it is Needed

Many actions can be taken in the field of agricultural production to increase its efficiency and produce more, to utilise agricultural land which today is considered marginal or unproductive, and to maximise the efficiency of the use of agricultural resources, so making available more food of the right kind to the population. All this can be done, and FAO is helping to do it. One thing, however, should be made clear regarding the question: 'will food production be able to keep pace with the population growth?' When asked on a world basis, it may be of little practical significance. More important than total production on a world basis, are the possibilities for those countries and regions with the lowest levels of food consumption to improve them through agricultural and economic development, so as to eradicate the problems of malnutrition. Otherwise, the fact that Europe or North America or Oceania could double their agricultural production in the next 20 years would alone add little to the welfare of the under-developed regions.

The foregoing considerations are not intended to be pessimistic, but only to point out the obstacles likely be encountered in fulfilling a task which is not impossible. However, two aspects of the problem must be emphasised. The first one is that it has to be considered on a country basis, and that it is no more logical to speak about 'overpopulation of the world' than it would be to talk about 'world surpluses' at the present time. By that, it is meant specifically that the problem of balancing economic, including agricultural, expansion with population growth needs to be attacked on a country by country basis.

The second aspect is that some countries now have such a rate of population growth that it hampers their efforts towards economic development, which is necessary if their populations are to be fed at a desirable level. The cycle of poverty, malnutrition and low productivity has to be broken somehow. International assistance can, of course, be of great help in breaking this vicious cycle. It has also been suggested that controls on the rate of growth of the population are needed so that world economic and agricultural production can keep pace with it.

FAO is emphasising the first approach in the Freedom from Hunger Campaign which will run for five years. At a World Food Congress to be held in Rome in 1963, there will be a stock-taking of the results achieved by then and what remains to be done. It is obvious that within this brief period the task of freeing the world from hunger cannot be fully accomplished. What we are aiming at is the laying of a secure foundation for sound policies and practical action towards that ultimate aim. It is in the light of this aim that I appeal to the people all over the world to cooperate actively in the Campaign and to contribute towards its success. I am convinced that public response will be equal to the challenge that confronts us all today.

Learning something about nutrition. In Ghana, a village class attends a demonstration given by a local woman who has been trained by FAO.

Rice is the staple food of millions. Here a basket is weighed and the temperature of the rice recorded, in Burma, where FAO sent experts to work on grain storage problems.

PEOPLE LAND AND RECLAMATION

by **L. Dudley Stamp,** C.B.E., D.Lit., D.Sc., LL.D., Ekon.D.

Undoubtedly the greatest problem before the world today is the rapidly increasing pressure of population on land and land resources. Thanks to the increased skill and influence of the medical profession in the widest sense, the knowledge and practice of death control, with the elimination or control of so many of the old killing diseases, have overtaken the spread of the knowledge and practice of birth control, with the result that the world's population is increasing at a net rate unparalleled in history.

With the taking of the 1953 Census in China the last of the great population 'unknowns' was eliminated. With confidence that the error probably does not exceed ± 2 per cent., and certainly not more than 5 per cent., we may say that the world's population at mid-1960 was of the order of 2,900 million. Whilst net rate of increase is less accurately known, latest United Nations figures show its continued upward trend, so that it is now 1.6 per cent. per annum, or even approaching 1.7. This means a net annual increase of at least 45 million—125,000 a day, or 5,000 an hour. The pessimists refer to this in terms of new mouths to be fed, the optimists in terms of brains or pairs of hands to work.

Against this picture of the expanding human race is the fixed area of the land surface on which it must live, and which must provide not only the food but the many other needs of mankind which involve the use of land. Coincident with the expansion in numbers is the rising standard of living with the consequent demand for both more and more varied food, for more spacious layout of homes, for land for national parks and the various phases of recreation, for improved facilities for movement in roads and airfields. When a single issue of a single newspaper may use the timber of 10 acres of forest, it becomes obvious that pressure on forest land is scarcely less than on food-producing land, and is likewise increasing. At vast expense, as in the reclamation of the Zuyder Zee, tracts important in themselves but small when seen on a world scale may be added to the land surface, but by and large the world's land area is known and inextensible. There are no new lands to be discovered.

If each of the present 2,900 million inhabitants were given an equal share there would still be some 12½ acres a head. About a fifth of this is ice-covered or with permafrost soils or otherwise too cold to support normal agriculture. Another fifth is too arid (UNESCO's estimate is 23 per cent.), and with no known sources of water for irrigation; another fifth too mountainous or elevated, another tenth is bare rock or with soil inadequate for cultivation. The *ecumene*, or habitable earth's surface, is thus about 30 per cent. of the whole, or about four acres per head.

At the present time between 1.1 and 1.2 acre per head of this is actually cultivated by hand, the plough or by systems of grassland management. Remembering that the proportion used for non-food crops such as cotton, jute and rubber may be set off against the contribution to human food supplies from the animals of the unimproved grazing lands, we may say that it takes the produce of rather over one acre to feed one human being. This is, of course, averaging all the varied diets, the varied standards of living and the wide range of farming techniques throughout the world, but it is a useful yardstick with which to measure national needs and achievements.

Human beings think in terms of daily food, whether it be one, two, three or four meals a day, and the nutritionist in daily intake of calories and protein. The farmer thinks

An experiment in dune fixation, near Tripeli, Libya, using Saccharum aegyptiacum, *is shown in the foreground of this picture. A similar experiment had previously been carried out on the dunes in the background, using various grasses.*

in terms of seed time and harvest, and the adaptation of his cycle of activities to the annual cycle of the seasons, and so to his annual production.

Calorie Intake

Basically human food comprises the protein needed to build up and maintain the human machine, calories to provide the fuel to keep the machine going, and a range of substances in small quantity to maintain the whole in healthy working order. Although for some races long habit demands a balance of animal and vegetable protein, at least half mankind are actual or near vegetarians, with a protein intake almost exclusively of vegetable origin. What matters is the adequacy of the fuel: the calorie intake. Provided the diet is of sufficiently varied origin protein intake is likely to be sufficient if calorie intake is adequate, whilst deficiencies in other dietetic needs can be corrected with relative ease. But if the calorie intake is inadequate, the whole working of the machine is impaired. I make no excuse therefore for stressing the need for *enough* food, and to facilitate comparisons between varied diets have suggested the use of a Standard Nutrition Unit (SNU) of one million Calories farm output per annum by the farmer. Allowing 10 per cent. wastage in preparation and cooking, and for seed, this is equivalent to 900,000 Calories available for consumption, or 2,460 per day—a good average nutritional standard.

The use of this unit enables the 'carrying capacity' of land in terms of human beings to be measured and compared irrespective of the constituents of diet. Some diets are much more extravagant of land than others. In general, animals are poor converters of vegetable material into human food, so that meat and milk diets are generally extravagant of land compared with cereal diets. Thus the intensive rice culture of the Japanese with protein from beans (supplemented by fish) enables 6-7 SNU per acre to be produced; in north-west Europe intensive wheat cultivation for bread, with vegetables and fruits, can support four persons per acre, whereas under extensive North American agriculture, with emphasis on meat, it may require three acres to support one person—the ratio between the extremes is at least 20:1.

It is not difficult to calculate that with the present rate of population increase there will be over 6,000 million people by AD 2000, and that within the space of a few hundred years there would be standing room only. Whatever the long-term solution may be, the immediate introduction of world-wide birth control and family planning would not remove the problem of the moment—the elimination of hunger, which is the daily lot of at least a third of mankind, and the feeding of the additional millions of the next few years being kept alive by medical skill.

The question how many people can the world support is largely of theoretical interest as long as there exist national barriers. It is easy to see that if all the *ecumene*, or that part of the earth's surface with sufficient heat, moisture and soil, were brought under cultivation the cultivated area could be trebled. If existing knowledge and techniques were applied yields could be at least doubled, probably trebled, on land already in use. Such increase is most readily possible in the temperate lands or mid-latitudes where land-, soil-, and crop-management are best understood. This takes no account of expansion of production which must inevitably result from research in

progress—especially through application of genetic studies, the chemicalisation of agriculture and the cultivation of the sea.

Sociological Problems

The greatest obstacles are sociological, not technical. Two examples will suffice to prove this point. The fragmentation of holdings, usually due to old inheritance laws, prevents economic or efficient cultivation, but is proving very difficult to change. Secondly, there is the attitude to animals especially where, as over much of Africa, they are regarded mainly as symbols of wealth, and have little practical use.

Within the past two or three decades the number of agricultural horses in Britain has dropped by about a million: we may say that as a result a million acres of land have been released for food production. In India and Pakistan there are about 250 million cattle and buffalo whose main use is as plough and draught animals. Though they manage to exist on a minimum of food, some fodder must be grown for them and it is difficult to escape the obvious deduction that even partial mechanisation would release an area for the production of human food which might exceed 100 million acres. Put into other words, the pressure on the land in India and many other countries is far greater than even the vast number of human beings would suggest. Some writers have attempted to convert the animal population into an equivalent of human beings.

The result is usually to heighten the already startling contrasts between the nations. In a land-rich country like the United States every citizen has a heritage at present of some 12 acres (probably six potentially cultivable) and more than three already in crops or improved farm land. In England and Wales land of all sorts is only 0.8 acre per head, of which a little over 0.5 is in crops and improved grass. The extreme is seen in Japan—1.1 acre per head, perhaps 0.2 potentially cultivable, 0.17 actually cultivated. Yet on this the Japanese contrive to produce the bulk of their food needs: admittedly with a monotonous and mainly vegetarian diet, and with very few domestic animals and very little meat or milk in the diet.

Conservation and Reclamation

Two dominant words of the moment are conservation and reclamation. It might almost be said that 'conservation' is a by-product of the American depression of the 'thirties, when the spectacle of the soil being blown away from once rich prairie grasslands foolishly ploughed, or rainstorms cutting gullies and likewise sweeping age-old soil into the rivers and the sea, served to divert public attention from any shortcomings of the government of the day or yesterday. From meaning just the preservation of soil from destruction, conservation has come to cover the preservation of the land and its resources for the benefit of future generations, including the conservation of the natural flora and fauna otherwise doomed to early extinction in so many parts of the world.

Reclamation might better be called 'clamation', if such a word existed, since it means claiming for man land which has hitherto done little to serve his needs. First and foremost it includes the extension of the cultivable area and takes on many forms. There is first the diking and draining of shallow seas, estuaries and lands liable to inundation, an art long practised but where studies of applied geomorphology are beginning to aid the engineer.

There is, secondly, the bringing of irrigation water to the arid lands where seemingly simple problems are found to be exceedingly complex. Water may bring life to the land, but water-borne diseases to the people unless doctor and engineer work closely together. A few years may see a costly reservoir silted up or good soils rendered useless by accumulation of salts: it would seem that far too much attention has been paid to the prevention of erosion, and not nearly enough to the controlled deposition of the eroded material.

What I have elsewhere called the pedological paradox remains an unresolved problem: do we aim to encourage the development of a soil with its natural micro-flora and micro-fauna—to keep the land in good heart as advocated by Yeomans in Australia—or do we aim at a mechanically suitable mixture of mineral particles designed simply to hold roots fed by solutions of requisite nutrients? In either case it would seem that soils of adequate depth and right texture—free working loams—assume greater significance than ever, and justify efforts to conserve good agricultural soils, unless we undertake the wholesale manufacture of soils by earth-moving machinery mixing the right ingredients.

Or will the future be with soil-conditioners which change the mechanical composition and behaviour of soils? Though already in full swing, the chemicalisation of agriculture has a long way to go. The provision of minute quantities of essential trace elements, and the elimination of equally minute quantities of noxious substances, have already rendered usable vast areas of formerly useless land, but the conditions best understood to date are those of the so-called temperate or mid-latitudes. The tropics, humid and arid alike, continue to present a major challenge to reclamation.

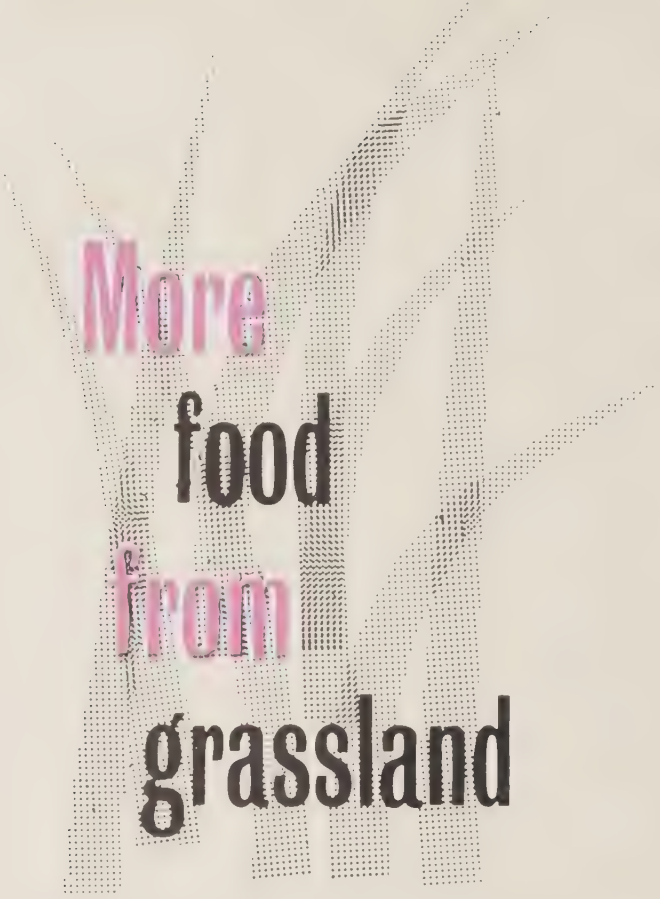
In 1960 began the Freedom from Hunger Campaign of FAO. It is clear that we already have the knowledge to free mankind from hunger if only farmers the world over can be reached, and certain of the barriers created by national frontiers are eliminated. In many parts of the world there is a vast potential of food production, but the uneven distribution of that potential presents the old political problem of the 'haves' and the 'have-nots'—another challenge to mankind.

REFERENCES

Most of the topics briefly mentioned above will be found more fully considered, with references, in the author's Our Developing World, *Faber, London, 1960. Pioneer work in attempting to assess the pressure on land of domestic animals in terms of equivalent human beings has been carried out by Professor G. Borgström of East Lansing, Michigan.*

A remarkable example of soil erosion caused by deforestation, near Bogota, Colombia.

What can be done by reclamation: rice growing on land in the Amazon Basin, Brazil, reclaimed from jungle.



by **Professor M. McG. Cooper,** *University of Durham.*

Pasture is the most important single crop in world agriculture and for many countries its exploitation through sheep, cattle and goats is a principal source of income. Sometimes, however, it can scarcely be designated a crop, for instance in the nomadic areas of Africa where natural growth of pastures is accepted like water and fresh air, without any conscious effort towards improvement on the part of the herdsman. At the other end of the scale, as in New Zealand, pasture is a climax crop and great efforts are made to maintain a high level of productivity.

In New Zealand pasture is mainly permanent or of very long duration, but in other countries where there is a greater pressure on land, pasture becomes a rotational crop, integrated with tillage cropping; under these conditions it may have a duration of only a few months (for example, berseem in the irrigated areas of the Nile Valley) or it may have several years of life, as in the British ley-farming system. Here pasture has more than its direct function of providing food for livestock for it has also another of restoring structure and fertility to land that has been exhausted by cropping. In this, legumes are of enormous importance because of the capacity these plants have to fix atmospheric nitrogen, not only for their own use but also for that of companion grasses, as well as for the use of a following crop.

In this soil enrichment process the grazing animal has an important part to play for a high proportion of the plant nutrients, especially nitrogen and potash, are returned in the excrement to give a high availability of plant food. Stapledon, in preaching the doctrine of ley-farming in Britain, repeatedly stressed the part of the clover ley and the grazing animal in building up soil fertility; while Sears' work in New Zealand gave factual evidence of its importance in sustaining productivity in established grass.

Temperate agricultural zones with reasonably adequate soil moisture are fortunate in having a wide variety of legumes which may be sown alone or as companions to grasses; but in tropical areas one of the biggest problems in pasture improvement is the introduction of edible leguminous plants, with a high degree of persistence, which will be companions to grasses. Unfortunately for those parts of the world, the application of nitrogenous fertilisers, though generally efficaceous, is expensive. One can appreciate the value of the legume in this context when one remembers that, under favourable temperate conditions, white clover in mixed swards will contribute a nitrogen equivalent of a 15-25cwt. dressing of sulphate of ammonia per acre.

The Grazing Animal

It is not easy to generalise on the broad problems of increasing pasture productivity because of the wide variety of conditions under which it is grown. Not only do these conditions affect pastures directly, but also the animals that graze them. For example, it might be possible in some tropical area to create a good pasture but we cannot expect to obtain the level of milk production that we would get from the same amount of nutrients grown under temperate conditions, because we have no high producing dairy cattle that are adapted to tropical conditions. Pasture is not an end-product in itself but an intermediate product in the process of producing milk, meat and fibre, and so its utilisation everywhere is conditioned by the general well-being and genetical quality of the stock that graze it.

Unfortunately, though we know that the grassland areas of the tropics and sub-tropics have an enormous potential, we are still very far from realising it. Apart from the first problem of improving the quality and quantity of pastures and extending their availability, either *in situ* or as conserved products, there are vast problems of animal disease control and of livestock selection—as well as the socio-economic problems of encouraging the indigenous peoples of these areas to apply what is already known to making their grassland more productive.

Considerable progress has been made already in several directions, such as immunisation programmes for disease control in cattle and sheep, the development of productive new breeds like the Santa Gertrudis cattle with a high measure of heat tolerance, and the introduction into new areas of promising species like pangola grass and centrosema. In some of the more favourable tropics, e.g., the West Indies, Brazil and Queensland, some impressive results have already been obtained. Queensland, with a strong economic incentive to give momentum to the work, has probably the most impressive record of all. Fortunately

it is not bothered with tsetse flies, and with them trypanosomiasis, as are large areas of tropical Africa. An effective control of this disease would effectively double cattle productivity in the tsetse belt of Africa.

Another huge category of natural grassland has its own special problems. This is to be found in semi-arid areas of countries like the United States, Russia, Australia and North Africa. Here, in the absence of irrigation, moisture is the principal limiting factor, and extensive grazing must be practised. The recent World Grassland Congress has shown that very considerable progress is being made with such pastures through the introduction of new plants and controlled grazing. Conditions, however, are generally unfavourable for the intensive methods that are adopted in more favourable areas, such as top-dressing and close subdivision. The emphasis must be on livestock which are well adapted to such conditions, such as Merino sheep. One of the big problems in such areas is the creation of emergency reserves of fodder to safeguard against droughts, with their often catastrophic losses of stock.

After the problems of such difficult environments, those of the temperate grassland areas, where there is a reasonably adequate rainfall, appear to be trivial. Yet in these regions we are very far from realising the economic potential of pasture, except perhaps in the Netherlands where a severe pressure on land is being met by a body of farmers with a good knowledge of the principles of pasture and livestock management. It is true that there are many farmers in Britain, New Zealand and Australia who are getting first class production from their grassland, but invariably they are well out-numbered by neighbours who still have a long way to go. It is generally characteristic of grassland farming that there is a wider range of production and profitability than there is in cash cropping because of the complexities that animals introduce. It is not easy to be a top-grade grassland farmer.

Two Basic Problems

Basically, the problem of producing more from pastures boils down to two main issues. The first is production of more grass of high nutritive value, and the second is the more efficient utilisation of what is produced by appropriate methods of grazing and conservation and by good livestock husbandry. On the production side the principles are well defined. Good pastures will not grow in waterlogged or acid soils, so these faults must be corrected. If soil fertility is deficient, not only is the balance of species upset with the encouragement of less desirable species, but also, total production falls.

Formerly we thought of soil fertility in terms of the three major elements, nitrogen, phosphorus and potash, but research over the past decade has shown that minor elements such as sulphur and molybdenum may have a critical effect on pasture productivity. On some soils in New Zealand, for instance, the application of no more than a few ounces of molybdenum per acre, on land that was otherwise adequately fertilised, has more than doubled productivity because of the role this element has in influencing vigorous clover growth. Without a good growth

Contrast in grazing. Above, *a Masai herdswoman builds a thorn hedge to keep cattle in an unimproved grazing area.* Below, *a good sward which has been obtained by clearing land and planting improved grass species.*
(Photo: Central Office of Information, London)

of clover the only alternative to high production is a heavy application of nitrogenous fertilisers, but in countries where these are expensive in relation to the value of the production their use becomes uneconomic.

Fertiliser Nitrogen

This raises a current issue in grassland practice, namely the conflict of thought regarding clover and fertiliser nitrogen. Under reasonably good British conditions a ryegrass/white clover pasture, without artificial nitrogen, will produce about 6,000-7,000lb. of dry matter per acre at the grazing stage. If small quantities of nitrogen are applied, i.e., 3-4 cwt. of sulphate of ammonia per acre, there will not be an appreciable increase in yield, though, according to the timing of application, there may be a better spread of yield, which may be an economic advantage. It is only when considerably heavier rates of application are made that there is an improvement in both amount and spread of production. Repeated dressings at intervals, amounting to not less than 10cwt. of sulphate of ammonia per acre per annum, will, under British conditions, raise dry matter production by about 50 per cent., i.e., to a level of 9,000-10,000lb. Under New Zealand conditions this level of production is obtained without the use of bag nitrogen and this is a reflection among other things of the very much longer growing season in that country.

Because the cost of fertiliser nitrogen in New Zealand is high, management is directed towards maintaining a vigorous growth of clover in pastures. In Holland there is a very different approach, for the emphasis there is on fertiliser nitrogen. This is a reflection of several factors, including the low cost of fertiliser nitrogen, the less favourable conditions for clover growth, and the emphasis on dairying which is the most intensive method of converting pasture into a saleable product. In Britain, the tendency is to follow a compromise between the Dutch and New Zealand systems—i.e., to use liberal nitrogen dressings on early growing species like Italian ryegrass, and to rely mainly on clover with the longer general purpose types of pasture. There is, however, a small group of dairy farmers who follow Dutch practice, and usually these are men who achieve a very high level of production per acre.

Grass Utilisation

Turning now to methods of utilising grass, here again there are differences of opinion as to the best system of grazing. It can be said fairly definitely that the most productive system is one that allows the leaf to do two jobs, i.e., feed the parent plant as well as the grazing animal. This will usually involve some form of rotational grazing, either by the use of the fold fence or close subdivision. The aim should be to graze a pasture fairly quickly but not necessarily completely, and then to give a period of recovery. At the same time management should seek to offer leafy growth to stock at all times because once a pasture runs to head quality falls. This involves a judicious use of the mowing machine, not just for conservation but to keep pastures juvenile. It is here that silage making is so valuable because it gives younger and more vigorous aftermaths.

It is in the provision of a leafy succession of nutritious pasture that the skill of the good grassland farmer is demonstrated. Under British conditions he can easily achieve a net output of 500 gallons of milk per grassland acre, while under the more favourable New Zealand conditions yields of 700 gallons of milk are possible. Average levels are probably at about half these figures and indicate the tremendous scope that exists for increased production. It is important to remember that high production per acre is obtained by high stocking rates rather than from high individual production, a fact that is not sufficiently appreciated by a great many farmers. This accounts for some of the prejudice that exists among livestock fatteners against intensive grazing methods, for it is generally the rule that better finish can be obtained from non-rotational than from rotational grazing.

The explanation for this is possibly a disturbance factor through the movement of stock, and with it fluctuations in plane of nutrition as one pasture is eaten out before a transfer to a fresh pasture. It was to avoid this fluctuation that the new technique of rotational creep grazing for lambs was evolved. In this the lambs, while they are on their mothers, have preferential access to fresh grazing before the ewes are allowed their turn. Live weight gains exceeding 800lb. per acre have been achieved in the North of England by this method, which is probably the most efficient means we have of converting pasture into meat.

Reference has been made to the toll of disease under tropical conditions. Temperate grassland is not without its own disease problems, but fortunately enormous strides have been made in their control. There are now effective vaccines for the enterotoxaemias, and most of the parasitic worms can be controlled by drenching or by management. The most serious group, with only incomplete control, are the so-called metabolism diseases such as grass tetany. Even here considerable progress has been made in getting a better understanding of cause and prevention.

Dr. William Davies, in a plenary paper at the Eighth World Grassland Congress, forecast that production figures of the order of 900lb. of live-weight increase would be feasible from an acre of grassland if all known techniques were applied. The evidence does not deny this but the essential question to be answered is: can such levels be achieved economically and with profit to the farmer? The answer is probably in the negative at the present time, but as the pressure on land grows with increasing world population, and we come to value milk and meat even more highly than we do today, the incentive will be there, along with more enlightened management both of livestock and pastures, to realise to a much greater degree the potential of the world's pastures.

Grassland management was no more than an art up till 30 years ago. It still remains so for many farmers, and it is not always a very well executed art, but thanks to the work of a large body of research workers there is a growing body of knowledge which makes the management of pastures, to realise to a much greater degree the potential then we will realise more of its potential in the form of milk and meat.

Cattle grazing at the Veterinary Centre, Shinyanga, Tanganyika; they are a cross between Sindhi and local Zebu breeds. An FAO team has visited Tanganyika, Uganda and Kenya to advise on improving milk yields and consumption.

More food from livestock

by **C. P. McMeekan,** C.B.E., Ph.D.,
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It is inevitable that any series of articles designed to assist in meeting the ever-increasing need for food of an ever-increasing world population should direct special attention to milk and meat. There are two basic reasons for this. Proteins of animal origin have a special and at present an irreplaceable biological value in the nutritional well-being of humans. Accordingly, the consumption of these two items in our diet increases as living standards rise.

Under these circumstances it is more than unfortunate that the farm animal is relatively so inefficient in converting raw material to human food stuffs. This is especially so when the animals in question (like the hen and the pig) require a type of food which can be used directly by man, so that they enter into direct competition with him. While this is less true of the ruminant, which is specially adapted to the conversion of high cellulose- and lignin-containing roughages, and which therefore can make use of fodders which are useless to man, it is nevertheless a fact that all farm animals are competitive with man in the use of land. In this lies the very real problem of increasing animal production in those areas of the world which are so heavily populated that a large proportion of the food that is produced has to be in such a form that it is directly consumable by man.

Three Main Zones

In attempting to review the world potential for increased livestock production it is convenient to divide the usable areas into three main zones—the developed, the developing and the under-developed areas.

The 'developed' areas cover those like the countries of Western Europe, where a high technological standard in land use, and in particular in animal production, has been reached. Intensity of use is at a high rate, and a balance between crop and animal has been reached so that high-level soil fertility and productivity is continuously maintained. These are countries where there is no real shortage in a nutritional sense of milk and meat not only because of intensive local production, but because of the importation of food surpluses from areas coming into the second ('developing') category.

The 'developing' countries embrace the so-called new lands of the world where the overall agricultural potential is still far from being realised, and where existing populations are not yet large enough to consume even existing production. The American continent, Australia, New Zealand and other South Pacific areas come into this category. Here again there is obviously no shortage of animal foods for the people concerned. On the contrary, exportable surpluses of meat and of milk products are a general phenomenon. By and large, technological efficiency is at a reasonable level and follows the pattern set by the 'developed' countries.

The 'under-developed' areas, in contrast, cover the densely populated zones of Africa, Asia, India, South-East Asia and the Far East. In general, all these suffer from an

acute shortage of foodstuffs of animal origin and people are dependent primarily upon cereals for their existence. Techniques in agriculture are primitive by Western standards. Overall productivity is low. Animal production is peculiarly inefficient. Soil fertility decline rather than maintenance is a characteristic.

This arbitrary classification is obviously an over-simplification but it is sufficiently useful to provide a basis from which to approach the problem of increasing the available supplies of milk and meat to world peoples. Theoretically, an immediate short-term solution is obvious. Countries in the second category could materially assist countries in the third by supplying their deficiencies in animal products. Countries in the first category could also help by still greater increases in their efficiency and/or by reducing their intake of animal products from the second zone. Such an approach, however, is not particularly realistic at this stage in world development. It is impossible of attainment except in minor degree for social, political and economic reasons outside the scope of this discussion. At the same time it is of fundamental importance that this approach to the problem of meeting the world population explosion threat be borne in mind constantly by all concerned. It seems clear to any thinking person that no final and reasonable solution is possible without such interchange of available food supplies.

Potential Production

Irrespective of the outcome along these lines it is equally clear that milk and meat production must be stepped up to ever-increasing levels. In particular it must be raised to much greater heights in under-developed zones. What are the possibilities and what are the main requirements? On the question of potentials, it is no exaggeration to suggest that these are not only extremely great but are also impossible to estimate with any accuracy at the present time. Technological efficiency is improving at so fast a pace that the estimated potential of any country for annual productivity a few years ago is well out of date today. A simple example will suffice. When the writer began his association with the New Zealand dairy industry 30 years ago, the national average output of butterfat per acre from dairy pastures was about 80lb. and the target, based on best performance, was 200lb. Not many years elapsed before the output averaged 150lb. and the target became 300lb. Five years ago, the target was raised to 400lb. This year, the performance on one of the Ruakura Research Station farms reached 520lb., and this on pastures rated as relatively inferior by modern standards. The present national output stands at about 180lb. of fat per acre, a figure obviously capable of being trebled on a basis of existing 'know-how'.

There is no question that substantially larger outputs of milk and meat can be obtained from all three zones. Even in a country as intensively organised in an agricultural sense as Britain, the scope for much greater production is obvious to any animal man. This scope exists because of the very great variability in output per acre, per animal and per man on British farms. It is to be seen in the extensive areas potentially useful as pasture and crop land at present either unused or extremely inefficiently used. It is to be seen in the fact that increasing knowledge arising from organised research is constantly pointing the way to ever-increasing efficiency in livestock production. If Britain can be taken as a typical example of the countries of category one, the group is capable of even greater performance than so far attained. Their advanced stage of industrial and social development renders them well fitted to take advantage of the potential contributions from research.

Quantitatively, there is even greater scope for increased output from the developing zone. Within the American continent, intensity of production can be stepped up over most areas. Comparatively speaking, livestock farming in Canada and the United States is still on an extensive rather than an intensive basis. The same applies to an even greater extent to many South American countries. The temperate areas of Argentina, Chile and Uruguay are especially suited to meat and milk production and are still in a relatively undeveloped state. The sub-temperate parts of Argentina, Uruguay and Southern Brazil present a similar picture. Millions of acres have not yet received the benefit of artificial fertilisers; millions of acres still carry native, unimproved and relatively unproductive pastures, capable of tremendous improvement by modern cultural methods and by the introduction of better species and strains of pasture plants. The standard of animal management and the intensity, if stepped up to levels characteristic of the developed areas, could result in outstanding advances in the volume of animal products. To a similar degree Australia and New Zealand, Fiji and New Guinea can contribute an increasing output of meat and/or milk products when required.

What now of the third category countries? Can these help themselves by increasing their own output of animal products? The answer of any animal man who has had the privilege of visiting the areas in question is an emphatic 'yes', if he looks at the issue purely in a technological sense. The possibilities from a more balanced agriculture, involving the intelligent use of the animal and its efficient exploitation are so patent in every country concerned that no other answer is possible. The unused (for meat) and sadly inefficient (for milk) cattle of India are an obvious and outstanding reason for such an attitude. The simple device of halving the 400 million herd could quadruple the milk output. The potentials for grassland of the scrub-covered hills of Japan are another. The scope for sheep and cattle meat on the highlands of Ceylon are a third. The differences in efficiency of the 'native-owned' and 'white owned' cattle of Africa provide a still further example of the scope that exists. These simple illustrations can be multiplied a thousand fold.

Barriers to Progress

If the animal man in question, however, sees the problem in the light of the difficulties involved he is not so certain of his answer. He stands to be appalled, not by the technical difficulties involved, but by the social, political and economic forces that weight the scale against him. He

Primitive animal husbandry in Africa; production is unlikely to increase without the introduction of modern methods.

Water buffaloes at the Aarey Milk Colony, Bombay, being milked under modern conditions.

appreciates that he is not up against production, climatic or other environmental problems incapable of practical solution, but is faced by barriers imposed by completely non-agricultural issues—by barriers of religion, of tradition, of race, of prejudice, and above all by the barrier of ignorance.

This brings us to a consideration of the requirements for increased livestock production in under-developed zones. From what has been written, removal of the barriers mentioned is essential and here the barrier of ignorance must go first. The writer does not subscribe to the view so often expressed by some of the more famous travellers of British Agriculture that research is a prerequisite to better utilisation of the under-developed lands of the world. In fact he considers that countries of the 'developed zones' have done a great disservice to their less fortunate brethren of the under-developed zones by giving thousands of young men from these latter countries a training, not in the elementary principles of good husbandry (soil, plant and animal) but in agricultural research, in such a way as to make them relatively useless on their return to their native land. There is surely little merit in training people in techniques of research in sperm physiology or even in the art and mystery of artificial insemination, when the standard of nutrition and husbandry of the existing cattle populations is so deplorably low as to impose an ever-increasing burden on the countries concerned.

The principles of animal production are well established. These principles, as principles, apply throughout the world. By and large they are simple and their application relatively easy in any environment for a well trained animal husbandman. Their efficient application (without any more research) will raise the animal outputs of the developed and the developing zones. Their introduction into under-developed countries is a prerequisite to more milk and more meat from these areas.

The vast area of experimental ponds at the Tropical Fish Culture Research Institute, Malacca.

(Photo: T.F.C.R.I., Malacca)

More food from fish

by **G. A. Prowse,** Ph.D., *Tropical Fish Culture Research Institute, Malacca.*

That fish forms no inconsiderable part of the world consumption of protein is evident from the fact that in 1958 a total of 33,720,000 metric tons of fish were produced throughout the world (FAO, 1958). These figures leave no room for complacency, however, for whereas Europe, with a comparatively static population of 400 million, produces 7,490,000 tons, China, with a rapidly increasing population of over 600 million, produces 6,000,000 tons, and India, already some 380 million strong, produces only 1,000,000 tons. Moreover, these latter are the very countries where other sources of protein are short. The production of fish must be substantially increased to meet the demands of the undeveloped countries, whilst even in the more highly developed Western nations the present rate of production must at least be maintained. To achieve this, much intensive research is necessary.

MARINE SOURCES

The crop of fish taken by a fisherman is only the end product of a complex chain of processes. The beginning of this food chain is the fixation of light energy by chlorophyll-bearing plants, the 'primary production.' This is in part controlled by the amount of mineral nutrients available for plant growth. By a series of links—insects, crustacea, etc.—or by direct consumption, the plants are converted into fish flesh. To increase production we must therefore increase the amount of light-energy converted into fish flesh, a by no means easy task.

In the sea, from which five-sixths of our total crop of fish is derived, primary production is largely in the form of phytoplankton. From plankton and other studies we can hazard a guess at the potential productivity of fish in various areas. Some temperate waters seem fished to capacity, and any increase in fishing intensity may deplete stocks to below the level of subsistence from reproduction. Thus research should be aimed at fishing control and protection of spawning. In tropical waters, seemingly underfished, research is aimed at improving fishing techniques and developing new areas. In both cases the plotting of fish migrations is involved.

Thus marine research concerns largely the exploitation and protection of existing stocks, and only in recent years have attempts been made to increase the population by seeding fry in the sea (as is being done in the United Kingdom, at Lowestoft, with plaice) or by improving coastal feeding grounds with fertilisers. Both methods are subject to many chance factors and have limitations.

FRESHWATER

Inland waters are no less important, despite their lower total crop, and in Africa and Asia a quarter of the crop of fish is derived from this source. These are continents of vast interiors with poor communications, with communities far from the sea. Increased production in inland waters will substantially benefit such communities. By contrast, in highly developed countries with adequate protein supply, for example the USA and Britain, research, with the exception of salmon fisheries, is aimed more at game fishing. Nevertheless, in Germany and Central Europe, carp rearing is an important industry, and even in the southern United States fish farming plays an increasingly important rôle.

Rivers and Lakes

Of inland waters, the value of rivers and lakes can hardly be overstressed. It is doubtful if the fish resources of the great river systems of Asia and Africa have been fully utilised, and with good management these should be capable of much higher production. Good management implies a greater knowledge than hitherto of the biology and habits of the fish, and however academic this may seem it is vital for the best use of fisheries resources. Thus we can

A carp pond in Malaya. Animals are bred at the waterside to manure the pond.
(Photo: Fisheries Department, Malacca)

Traditional fishing boats and market at Cochin, India.

A three-and-a-half year old Indian carp, Catla catla*—an excellent pond fish.*
(Photo: T.F.R.C.I., Malacca)

encourage the best species and discourage predators. Dams create new problems to be solved by research. Migration of some species of fish may be assisted by fish ladders, but where breeding grounds or feeding territories are destroyed research may enable alternative sites to be constructed, with added advantages, such as protection from predators. In Canada and the USA, trout and salmon have been diverted to new spawning grounds by means of electrical barriers.

Rivers may be underpopulated, through predation, overfishing or lack of breeding grounds. Impounded waters often have a high production of phytoplankton (RZOSKA *et al*, 1955 [3]; PROWSE & TALLING, 1958 [2]) and theoretically could support a higher fish population. In both cases artificial stocking might be the answer. This must be so balanced as to allow regular cropping of fish, and leave enough to multiply and grow to a reasonable size, using to the full the primary production. It might well be done in the Nile with bolti (*Tilapia nilotica*) where also the pestilential 'nemittae' (*Tanytarsus lewisii*) might be controlled by suitable insectivorous fish. Schistosomiasis, the scourge of rivers and canals in Africa, could be controlled by introducing edible weed-eating fish, such as *Tilapia zillii*, thereby eliminating the breeding ground of infected snails.

Lakes can hardly be divorced from the feeder rivers, although large lakes may have some factors common to marine waters. Frequently, established commercial fisheries are present and their effect on stocks must be considered. In Lake Victoria it appears that any increase in fishing intensity may deplete stocks of the valuable *Tilapia esculenta* and *T. variabilis* below the level of subsistence against less valuable competing species (East African Fisheries Research Organisation, 1956-58). There is also some hint that the excessive destruction of crocodiles may harm fisheries through the increase of otters.

Swamps

Huge swamps such as the papyrus 'sudd' in the Sudan and Uganda, or mangrove swamps, are obvious choices for

fish culture, but the problems are less simple than would appear at first sight. Vast deposits of peat are formed from the dying vegetation under the anaerobic conditions produced by bacterial action in tropical swamps. Even after the swamp has been cleared, this peat, by its decay, may deplete the overlying water of oxygen. In such cases, only by using running water, or large open areas subject to wind action, can fish be successfully raised.

Such waters are usually acid and need liming, but the immediate effect of lime may be to increase the bacterial decay of the peat, thereby producing an oxygen deficiency, and only later will a more balanced condition result. Mangrove swamps are brackish and might be converted to the culture of milkfish (*Chanos chanos*) and prawns. Even here caution is necessary, for some prawns are believed to breed best in untouched mangrove.

Fish ponds

Possibly fish ponds may have the greatest future for the production of fish, for conditions can be more easily controlled, and the fish protected against predators. The judicious use of fertilisers and the use of supplementary food may increase production to a phenomenal level. In the Congo over five tons of fish per acre per annum have been produced. Moreover, fish ponds, because they need only static water, are useful in semi-desert regions as well as in regions of high rainfall. They are especially suitable for those areas where it is difficult to keep cattle, etc., either because suitable food is lacking or because of serious endemic animal diseases.

The species of fish cultured, and the methods of culture, will depend on the areas concerned, but in all cases the methods of culture are largely empirical, being derived from trial and error. Only in recent years has research been carried out to improve the methods.

In south-east Asia Chinese carp ponds are probably the most important, but virtually the same methods have been used for 2,000 years. The breeding of pigs is combined with the fattening of Chinese carps, food for the pigs, such as water hyacinth, *Eichhornia crassipes*, and kangkong, *Ipomea repens*, being grown in and around the ponds. Washings from the pigsties, and even added nightsoil, stimulate plankton for the silver carp (*Hypophthalmicthys molitrix*) and the big head (*Aristichthys nobilis*), whilst grass to feed grass carp (*Ctenopharyngodon idellus*) can be grown round the pond.

Such a system suffers from the defect that the carps do not breed in ponds, and all the fry have to be imported from China. In addition, the use of pigs renders the system unsuitable for Muslim communities, and it is far from hygienic. At the research station in Malacca grass carp have been brought to spawning point in a pond by subjecting them to a flow of water, and in Japan 'wild' fish have spawned in a mountain stream (KURONUMA, 1958 [1]). Alternative species have been sought, the most promising being *Puntius javanicus* and *Catla catla*. The latter has yet to breed in ponds, but is easily obtained from Indian rivers and canals.

Of other species, perhaps the genus *Tilapia* is most valuable. In Africa, where the genus is native, *Tilapia nigra* and *T. mossambica*, both algal feeders, and *T. zillii* and *T. melanopleura*, both grass-eaters, have proved very suitable for pond culture. In Israel, the species used are *T. galilea* and *T. nilotica*, and in Asia *T. mossambica* takes pride of place. All species suffer from the disadvantage that they breed too freely, and a pond will soon be overcrowded, causing 'runting' of the fish.

Mono-sex culture improves matters, but sexing is tedious. VAN SOMERON (1958 [4]) recommends selecting runted males when they are in breeding dress and finds that they grow very fast when transferred. In Malacca, the Malayan strain of *Tilapia mossambica* has been crossed with a closely allied strain from Zanzibar: the offspring grow about twice as fast as the parents, and if a Zanzibar male is mated with a Malayan female all the progeny are male. Thus a practical method has been found to produce a mono-sex culture without the tedium of sexing; in addition, these fish grow very quickly. Besides studying the genetics of the cross, selection is being carried out to improve the parent strains.

In Indonesia and the Philippines, vast coastal areas are given over to brackish ponds for the culture of milkfish (*Chanos chanos*) and grey mullet (*Mugil cephalus*). The fry are trapped in ponds as they come in with the tide, and the ponds can be fertilised to stimulate the growth of algae and other food organisms. In addition, protection against predators is possible in such ponds. This dependence on the adventitious appearance of fry is not ideal, and more research should be devoted to methods of breeding stocks.

Padi Fish

Rice is a staple crop in much of Asia and the inundated land given over to rice culture often supports a crop of fish as well, mainly *Trichogaster pectoralis* and *T. trichopterus*. Such fish are small and hardly of economic value, but the fish could be improved with intensive research. Holding ponds might carry the fish over two seasons, whilst the fish may be improved in size by selection. Other species could be used; *Tilapia mossambica* has proved successful in some areas. Research on this aspect of fish culture has hardly begun.

Finally—a plea for more research stations and research not tied to the direct short term demands of fisheries departments. It is not always easy to appreciate the value of seemingly academic research, but it has nearly always proved vital to the success of long-term fisheries projects. Such research should not be hampered by short-sightedness and lack of financial support.

REFERENCES

1. KURONUMA, K. Spawn taking of Chinese Carp in the Tone River, Japan. I.P.F.C. *Current Affairs Bulletin* No. 22, 1-4, 1958.
2. PROWSE, G. A. and TALLING, J. F. The seasonal growth and succession of plankton algae in the White Nile. *Limnol. and Ocean.* **3**, 2, 222-38, 1958.
3. RZOSKA, J., BROOK, A. J. and PROWSE, G. A. Seasonal plankton development in the White and Blue Nile near Khartoum. *Proc. Int. Assoc. Theor. Appl. Limnol.* **12**, 327-34, 1955.
4. VAN SOMEREN, V. D. and WHITEHEAD, P. J. P. The culture of *Tilapia nigra* in ponds. 1. Growth after maturity in male *T. nigra*. *E.A. Agric.J.*, **24**, 1, 1959.

More protein food from plants

1. The Field Surveyed

by **N. W. Pirie,** F.R.S., *Rothamsted Experimental Station.*

Everyone with experience of the under-developed areas of the world has seen in them evidence of hunger. The experts disagree to some extent about its scale and origin; some say the people are feckless, others that they are feckless because they are hungry; some say that many races are small and so need less food, others that they are small because they are hungry; some say the troubles arise from diseases and parasites, others that a properly fed person is not so readily attacked by those diseases and parasites. The argument goes on in many forms and there is probably some truth in all the contending points of view. But the first step, both towards getting rid of the obvious hunger and towards finding out the truth, is to make more food available.

The need for more food will become still more acute as the population of the world increases. Again, there is disagreement. Some say that it should not be allowed to increase, others that every increase is to be welcomed. Here we are dealing with matters of preference and opinion but the stubborn fact, that everyone concerned with nutrition should bear in mind, is that population probably will increase. The main reason for this is that, as knowledge of hygiene spreads into the developing parts of the world, it will be used. This has no necessary connection with medical knowledge. Cretans 3,000 years ago, Romans 2,000 and Europeans 300 years ago knew little reliable medicine but they had noses, and when they had the technical skill to get clean water into a city and sewage out of it, aesthetics led to improved health and an increasing population. Similar motives, reinforced by medical knowledge, now operate throughout the world. The birth rate remains much as it was, but many fewer babies die in infancy and the population increases.

Ultimately contraception will become reliable enough, and will be used widely enough, to establish satisfactory equilibriums. But that will take time, and in the meantime babies are being born at a rate that strains the originality of popular writers in search of yet another graphic numerical analogy.

Ways of Producing More Food

The obvious way to get more food for this growing population is to bring more land into cultivation; that was what man did when he spread agriculture all over the world. The next step, as the king of Brobdingnag pointed out to Gulliver, is to grow more on the area already being farmed. After that we must protect what we have grown. Ancient authors, in the Bible for example, were well aware of pests and diseases but regarded them as uncontrollable and unusual visitations. We now recognise that the regular, steady, loss of food from these causes is as important as the loss from catastrophes and we are slowly finding out how to diminish it.

These three ways of getting more food have an accepted place in the research policies of many countries and of the international organisations. For that reason, and also

because aspects of work along these lines are discussed by others, they will not be considered further here. Like most socially useful branches of science, they are stinted; liberality is reserved for such things as space travel, and nuclear bomb manufacture. Two other methods of producing more food get even less support—these are synthesis and the direct and more economical use of crops that we already grow.

Synthesis is an imprecise word. It is sometimes used as if it could only mean making something directly from the elements or from very simple substances. This is total synthesis and it is, in the main, what plants do. Many substances are now made directly from water and limestone or coal and a few of them, acetic acid and alcohol for example, can be considered as foods in a small way. But, in spite of recurrent fantasy in the popular press, it is extremely unlikely that the main foods such as starch and proteins will ever be made more economically in a factory than in a field. This is simply a matter of economics; we need about 30 substances in a diet and all of them are synthesisable. It may be that a few more will be discovered but it is reasonable to assume that they will be synthesisable too. The reason for not contemplating large-scale synthesis lies in the proposition, 'Why do a job yourself when it is cheaper and easier to get a plant or micro-organism to do it for you?' There is no final answer and we may expect that each success in making a vitamin or other essential nutrient by total synthesis, or by partial synthesis from some readily available plant product, will be a stimulus to research on biological methods of production.

More Food Plants?

The food plants that are now grown extensively were all known to primitive man, though some of them have been considerably improved by modern breeding. They were chosen as food plants mainly because they gave some product, a seed or a tuber, that could be stored so as to tide over periods of drought or cold weather. With modern techniques of storage this limitation no longer operates so strongly so that choice can be wider. This means that leaves and immature flowers, which at present serve mainly to make meals more interesting rather than more nourishing, could play a larger part. Nothing but habit keeps this from being done in Europe and the USA, but in many parts of the tropics the familiar vegetables do not grow well. Immigrants to these parts tend therefore to depend on imports and the original inhabitants eat very little fresh vegetation.

Three courses could be followed to overcome this: more vigorous efforts could be made to introduce the vegetables already used in South China and parts of Indonesia; a wider range of temperate varieties could be tested in the new environment to see whether some that are not esteemed here would flourish in it; selection and breeding could be started on the local plants. The last is the most interesting approach. It involves doing quickly with modern techniques the job that took centuries by the hit-or-miss methods of the medieval gardener. These things will indubitably be done but, even under ideal circumstances, vegetables are only likely to supply 2-5 per cent. of the protein needed. They do, of course, supply other nutrients besides protein, but protein deficiency is the world's most widespread dietary fault so that attention may usefully be concentrated on protein.

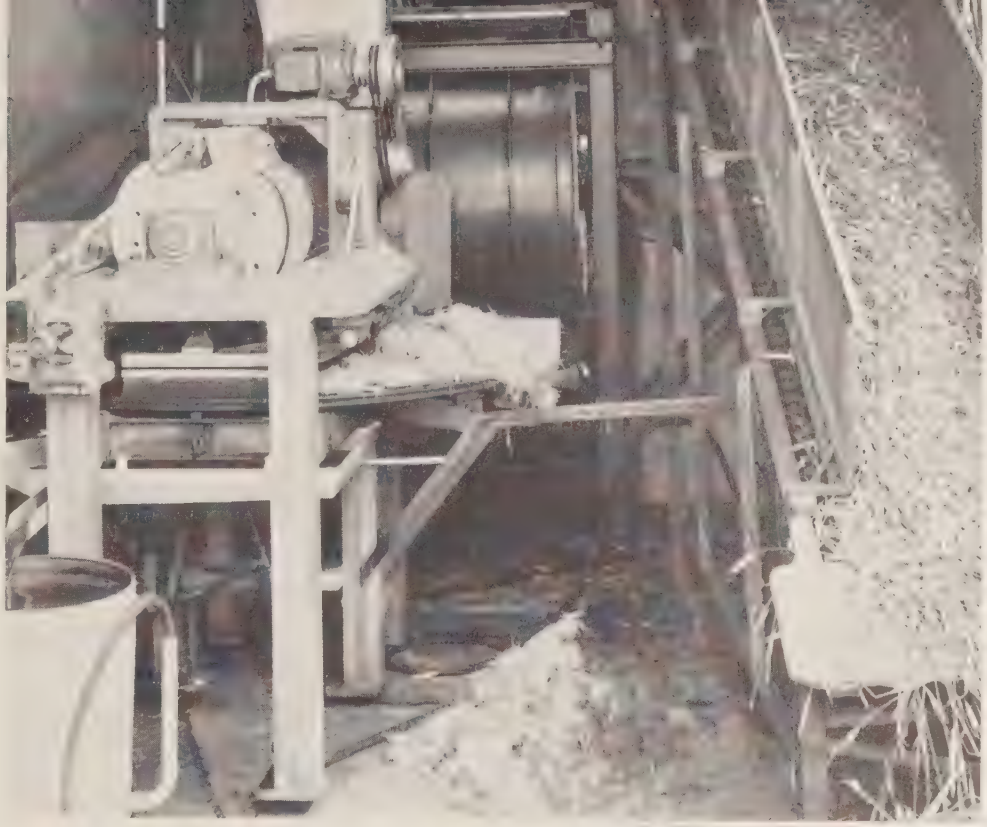
The possibilities of getting more food will not have been exhausted when adequate effort is put into growing and protecting crops because we often do not use fully all parts of the crops we grow, and those parts we use are often not used in the most efficient way. There is space here to consider only one example of each type of inadequate use.

Oil Plant Residues

Much of the world's vegetable oil supply comes from countries that need more food. The immediate reaction to this anomaly is to think that a food crop should be grown in place of part of the cash crop; this change will probably come about slowly. There would, however, be an immediate improvement in the diet if the residues from these oil-bearing plants were used more fully, for they contain protein and starch. The methods used in the industry have a historical justification because, at first, oil was the only saleable product and it often had to be extracted in a distant industrialised country. The residue was originally either thrown away or used as fertiliser, as soya cake still often is in China. Gradually the situation has changed. Coconut oil can now be extracted within a few miles of the plantation so that the advantages of drying copra before processing need careful reassessment, and the value of oil cake in animal feeding is now well recognised.

The potential value of these residues as human food is less well recognised, partly for traditional reasons but mainly because flavour and nutritive value are so often damaged during the oil extraction. Commercial practice aims at getting out as much oil as possible and everyone who has seen and smelt oil expellers at work knows how often that results in a hard, singed, residue. If gentler methods of pressing were used the residue would be more valuable, though, because of the residual oil in it, it would be more perishable. In some parts of the world enlightened experts on nutrition are trying to get stable undamaged products into more general use, but much remains to be done.

Some crops, ground nuts and coconut for example, are palatable in the natural state. It is therefore easy to make the undamaged residue palatable and one wonders why so much effort is put into attempts to separate purified proteins from them for adding to human foods. Some oil must be removed if the material is to be used as a main protein source, but a diet should contain fats and starch and there is little point in carefully removing them from ground nut meal in the factory and then adding them back again in the kitchen. Other crops, soya and sesame, for example, are not palatable in the natural state though there are traditional methods for turning soya into a milk and a curd. Here there is much more scope for research, partly to adapt the traditional methods to technological practice and partly to develop new ones. The job is worth doing because the oil plants produce at least 10 million tons of



The author's plant protein extraction equipment at Rothamsted. The cereal crop in the conveyor is fed into a pulper (the drum in the background), whence it is passed to the press, on which can be seen some pulped cereal. This will be passed through the machine again for re-extraction. Protein-containing juice is pouring into the bin in the foreground.

protein annually. This is a tenth or more of the world's protein need. As will be seen in the following article, FAO and other United Nations agencies are studying this subject in some detail.

Leaf Protein

Leaves are the primary source of almost all our food but, because of the amount of fibre in them, they can only be eaten sparingly. The substances in them are generally regarded as intermediate stages, awaiting translocation to seeds or tubers, or conversion to animal products. We are accustomed to these foods and relish them, but movement or conversion wastes time, or food, or both. As soon as this is realised, the advantages of making food from leaves directly by mechanical processes are obvious. This is a logical extension of well-established processes such as the extraction of sugar from cane or beet, and oil from olives or soya.

During the last 20 years, work has progressed so far at Rothamsted and elsewhere that we now have machinery able to handle several tons of leaf a day and extract half to three-quarters of what protein is present. The protein is coagulated by heating or acidification and is then filtered off and washed. At this stage it is a dark green cake with the consistency and perishability of cheese. This is the form in which we generally use it in cooking but it can also be dried, canned or turned into a grey-brown powder by solvent extraction. The problems of presentation on the table do not arise because of the flavour of the protein, as that is relatively easily removed, but from its dark green colour. This, clearly, is a temporary difficulty. The appearance we accept as normal in foods is a matter of habit and convention and a food with a novel appearance will be accepted by most people when they have seen others eating it for a few years. That is to be expected *a priori* and the expectation is amply borne out by our experience at Rothamsted. Many who ridiculed the project of making leaf protein a few years ago now willingly eat dishes made from it. Naturally they say that the products offered have been improved, but the real change is psychological.

The value of a food protein depends on its digestibility and amino acid composition. Laboratory studies give preliminary evidence on these matters but the real criterion is animal and human experiment. Many completed experiments on rats, chickens and pigs show that properly made leaf protein has the value that its amino acid composition suggests. It is better than most of the seed proteins and as good as those of fish. Experiments on people are not yet complete but early results agree with the animal experiments.

These are two sources of protein—one little used and the other as yet unused—that could be exploited. The next step is to start production in areas with protein shortage and then to work patiently on methods of presentation suitable for each area. More hostility must be expected to proposals as radical as these than to extensions of the normal methods of food production; for they amount to a criticism of past practice for being misconceived in concept rather than for being done in old fashioned ways that can be brought up to date by some modern improvements. Furthermore, the foods offered will not be immediately welcomed; people have natural and justifiable suspicions. But the fact that there will be these delays is all the more reason for starting, on a modest scale, immediately.

More protein food from plants[1]

2. Pulses and Processed Foods

by **A. G. van Veen,** D.Sc. and **R. O. Whyte,** Ph.D., *FAO, Rome.*

It is widely known that in many economically underdeveloped countries protein malnutrition, especially in weaned infants and young children, is one of the most important nutrition problems. Suitable sources of protein-rich foods (such as milk) which could easily prevent this serious form of malnutrition are usually either scarce or expensive or both, and in many of these countries it is impossible, for a number of reasons, to produce sufficient milk at a reasonably low price and it will be so for a long time to come.

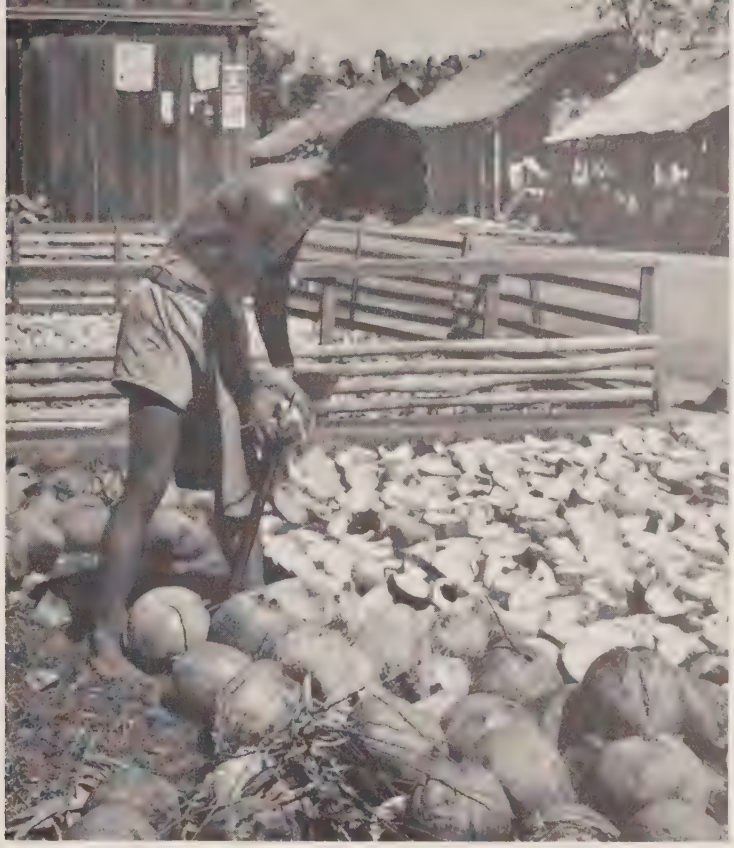
A few years ago, FAO, WHO and UNICEF recognised the need for additional locally available cheap high protein foods, either fresh or processed. Fresh foods would be preferred for most feeding schemes but problems of agricultural and horticultural production, of transportation and storage may often make it desirable to look for cheap processed foods. Processing, of course, makes the foods more expensive, but this may often be offset by increased keeping quality, ease of handling and storage, and prevention of waste.

Fresh Foods

The main crops which are available to provide cheap high-protein foods in the fresh state are, of course, the grain legumes, or pulses. These crops are already cultivated and used to a considerable extent in human nutrition in the tropical and subtropical regions; they feature in some of the better human diets in Africa; they are part of the basic food of tropical America and the Caribbean ('pinto', a mixture of maize and *Phaseolus* beans), and they represent a major source of vegetable protein in the vegetarian diet of the people of India. Nevertheless, a great deal still needs to be done if the wide range of genera and species which are available for most ecological conditions are to be permitted to contribute fully to a more balanced human diet.

The chief work of FAO in this field to date has been in Africa south of the Sahara. In November, 1958, at an FAO/CCTA Technical Meeting on Legumes in Agriculture and Human Nutrition held at Bukavu, in the Congo, it was recommended that Governments should promote urgently an increase in the total production of legumes already cultivated in the region. For this purpose, it was desirable to improve the statistics available on current production of food legumes, to give more support to fundamental research, to collect and disseminate information on methods of production, to conduct work on varietal improvement and to promote a policy of pro-

[1]With a note on protein of marine origin.



Coconuts are a useful source of plant protein; these are being broken open for drying on Mindanao Island, centre of of the copra industry in the Philippines.

Cowpea being harvested in Tanganyika. These and other pulses, with maize and sorghum flower, form the staple diet in many parts of tropical Africa.

(Photo: Central Office of Information, London)

Part of East Africa's groundnut harvest. This is one of the most nutritionally valuable crops grown in the tropics, both as a direct food and for export as an oil seed.

(Photo: Central Office of Information, London)

duction and distribution of seeds of the best cultivars of legumes adapted to different ecological conditions.

Both agriculturalists and nutrition specialists agree that the best grain legumes in Africa belong to the following species: *Arachis hypogaea*, *Cajanus cajan*, *Dolichos uniflorus*, *Glycine Max*, *Kerstingiellia geocarpa*, *Lablab niger*, *Lens esculenta*, *Parkia biglobosa*, *Parkia filicoida*, *Phaseolus acutifolus*, *Phaseolus coccineus*, *Phaseolus lunatus*, *Phaseolus vulgaris*, *Pisum arvense*, *Pisum sativum*, *Sphenostylis stenocarpa*, *Vigna Mungo*, *Vigna sesquipedalis*, *Vigna sinensis*, *Vigna unguiculata*, *Voandzeia*.

The species and particularly the cultivars in the other regions of the tropics and subtropics may be rather different—e.g., chiefly species of *Phaseolus* in tropical America, and of *Cicer*, *Phaseolus*, *Cajanus* and *Vigna* in India. The problems and potentialities are, however, similar and differ only in detail. Special mention should be made of the mineral nutrition of grain legumes in terms of the major and minor nutrients—an aspect on which more work is needed as to the requirements and responses of different species on different soil types. The rhizobial relationships of tropical legumes in general, and of grain legumes in particular, are very much to the fore these days in scientific discussion and research.

Grain legumes also have an important role to play in actions directed towards the diversification of monocultural cropping systems (and therefore also of diets)—those based on maize in Latin America, wheat and barley in the Mediterranean and Near Eastern regions, and rice in South-East Asia and the Far East. Grain legumes are, in fact, the first crop which can be recommended to cultivators with tiny holdings who can, quite understandably, see little economic justification for the much larger jump from monoculture to alternate husbandry involving complete integration of crop and animal husbandry.

Processed Food

FAO, UNICEF and WHO have also devoted attention to processed high-protein foods. In this connection a number of criteria have been evolved such as:

(1) The basic materials must be already available locally or be capable of local production;

(2) The processed foods must be within the economic means of the particular population group having the greatest need for protein, either to produce or to buy;

(3) They must be easily transportable and have a long storage life without refrigeration under conditions of heat and humidity;

(4) They must be completely free of any toxic or other deleterious influence;

(5) They must have characteristics of taste, odour, or physical properties that will make them acceptable food products;

(6) They must have such nutritional values as to be an effective protein supplement (to the main food); and

(7) They must be products not already being made the greatest possible use of as human food.

So far, seven potential food products have been studied in more detail. They are: fish flour; soya products; peanut flour; cottonseed flour; sesame flour; sunflower seed flour; and coconut protein. Whereas much was known about the nutritive value of these products, if processed carefully under well-controlled conditions, there were still many points which had to be studied before it could be stated under which conditions they might serve as food for human beings. With the help of the Committee on Protein Malnutrition from the US Food and Nutrition Board, and with funds of the Rockefeller Foundation, many or most of the research problems have been solved by now and for most of the products mentioned, tentative specifications have been drawn up.

Recently, several processes have been developed by which either fresh fish or fish meal are defatted. The deodorisation step can be omitted for groups that prefer a fishy taste in their foods, such as in South-East Asia and Africa south of the Sahara. These fish flours retain the high biological value of the starting material; they are stable in storage; and they can be incorporated into bread or other cereal products, or into soups or stews with good acceptability of the resultant food. Since these flours contain 70 to 80 per cent. protein, relatively small amounts are needed to supplement children's diets. It is estimated that fish flour can be produced for as little as 12 to 13 cents per pound. On this basis a supplement of 10g. per day (about 8g. of animal protein) would cost only about one-fourth of one cent, per day per child.

Peanuts, sesame, cottonseed and coconut are of particular interest since ordinarily they are processed for their oil, and the protein-rich press cakes, by-products of the oil production, are used mainly for animal feed or for fertiliser. If it is economic to use these materials for animal feed or fertilisers, it certainly should be economic to use them as human food if carefully controlled processing would produce a food suitable for human consumption. If even a part of this production could be diverted to human use, a substantial contribution might be made. However, many difficulties will have to be overcome, most of them technical. Many technical presscakes or defatted oilseed flours contain much impurity and dirt, or have been processed in the wrong way, i.e. the protein has lost a part of its biological value or digestibility. The final product will have to be acceptable to the potential consumer after having been incorporated in suitable foods or diets, typical for the region or area, and it is not always an easy, and is often an impossible job, to arrange for a statistically valid consumers' acceptance test. This, of course, also holds for fish flour.

And last but not least, when all these problems have been solved, there is the difficulty of starting promotion campaigns for these products adapted to local conditions and possibilities.

At the present time projects of this nature have developed or are developing in a number of countries with the assistance of FAO and UNICEF, for example fish flour in Morocco and Chile, peanut flour in W. Africa and India, cottonseed flour in Latin America and the Near East, and soy products (saridelee) in Indonesia.

Developments in the Rice Industry

Growing rice on a mountain: these rice terraces were carved by the Ifugaos in the Mountain Province of Luzon, Philippines. Some 400 square kilometres of rice are cultivated in this area.

by **D. H. Grist,** *formerly Agricultural Economist, Malaya.*

The cosmopolitan nature of the rice crop entails a wide range of problems, many of which are peculiar to comparatively small areas. A number of these problems will remain unsolved until fundamental work on soils has reached fruition. The former view that paddy makes no special demands on the soil is untrue, for there is growing evidence that soil characteristics are of great importance, especially in connection with diseases and response to manuring.

DUDAL (2) has summarised information on the genesis and morphology of paddy soils and has suggested the basis for a systematic study of the subject. He emphasises the

importance of a unified classification and nomenclature of paddy soils and suggests an appraisal of the distribution of the different soil units.

Paddy is now successfully cultivated on land previously considered unsuitable for agriculture. Mangrove swamps, peats and "muck" soils have been reclaimed. For instance, in France, waste land in the Rhone Valley (the Camargue) has been developed for paddy, thus opening up new prospects in a dying region. In Hungary, in a climate not entirely favourable for rice production and on eroded, barren, alkali soil, good crops of rice are now produced.

Although paddy is salt-sensitive, the crop may be grown in soil of high salinity if the irrigation water is of good quality. Breeding and selection to procure greater tolerance are engaging attention in a number of countries. Several such varieties have been isolated in the Philippines, in which country it has been noted that the plant is most sensitive to salt in the early seedling stage—pointing to the advisability of transplanting paddy from a nursery.

Paddy is employed as an initial crop in reclaiming saline soils. This is not a new development but it has found extended use in carefully-controlled irrigation and cultivation techniques. Thus, it is reported that there is a possibility of extending the Algerian paddy area tenfold by irrigating saline soils and devising suitable rotation of crops. Land reclamation of saline areas in northern Greece is being carried out by growing paddy as the initial crop. In Spain, the Punjab and many other areas, paddy is cultivated over a period of years on lands that have accumulated salinity.

Manuring

Much of the vast and increasing data on manuring paddy is of only local importance. Investigators in many countries have found that yields may be greatly increased by judicious use of fertilisers, but heavy applications, such as are used in Japan and a few other countries, cause an inequilibrium between organic and inorganic matter in the soil, resulting in an increase of worn out and low productive areas. To counter this defect it has been found necessary to apply organic and green manures. Recent evidence points to a wider appreciation of the value of fertilisers with organic matter.

In many regions decline of fertility results from the continued use of sulphate of ammonia on paddy land. Non-sulphate fertilisers, such as ammonium nitrate, urea and ammonium chloride are therefore gaining in popularity. In Japan, for instance, the use of ammonium chloride increased from 500 tons in 1949 to 48,800 tons in 1954.

Inoculation of seed or soil with nodule organisms is now considered necessary for satisfactory growth of legumes on soils never previously planted to such crops. In a series of experiments in India, green manuring increased the rice crop from 2 to 114 per cent., depending on the kind of green manure crop, location and soil. In Java, *Crotalaria juncea* grown annually increased yields by nearly 20 per cent. In Ceylon, 2½ tons of green manure per acre was more effective in increasing the paddy crop than four tons of either cattle manure or compost. Indonesian experiments indicate that the protein content of rice is increased with the quantity of green manure added to the soil. These and similar experiments have justified re-examination of the effects of green manuring in many countries.

Systems of Cultivation

In many regions, two crops of paddy are harvested annually from the same land. This system has tended to increase in regions provided with improved irrigation and suitable seasons. Indeed, irrigation sometimes makes it possible to obtain two dissimilar grain crops in a single year. Professor DUMONT (3) reports seeing in Italy a wheat crop with a yield of 55 quintals[1] per hectare harvested on 11th June, followed by rice transplanted two days later and harvested on 15th October with a yield of 93 quintals per hectare—a total of 148 quintals of grain per hectare in one year.

In some areas it is now customary to obtain a ratoon crop of paddy. The first crop is cut before all the green has left the straw and the land is then irrigated, which causes axillary buds to develop. Ratooning has increased appreciably in Formosa in the past few years and has also been developed successfully in the Swaziland Irrigation Scheme. Inseparable with any system of continuous paddy cultivation, of course, is the danger of build-up of a pest population.

Wherever semi-aquatic conditions prevail throughout the year, or where the nature of the soil precludes production of any crop other than paddy, the present system of annually cropping rice must continue. The highest production figures, however, are obtained in countries where paddy is grown in rotation with other crops. It is therefore probable that, despite methods designed to increase yields, such as breeding and fertilising, no great improvement in yield will be obtained unless crop rotation is introduced. This would be a revolutionary change of system in most parts of Asia and therefore difficult to inaugurate.

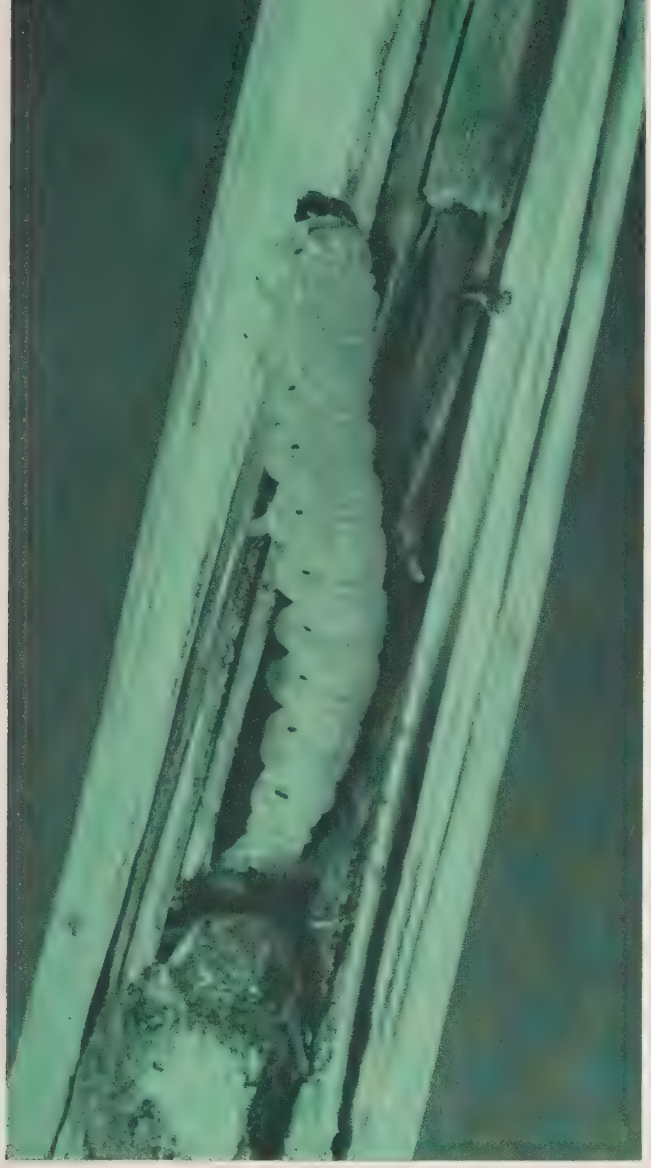
Weeds, Pests and Diseases

Wild Red Rice. In many parts of the world, and notably in North and South America, numerous varieties of wild rice possessing a red pericarp or seed coat have become so rampant that they are looked upon as the most serious of weed pests of paddy. They cause decline in yield and require harder milling, resulting in less head rice and more broken grain and bran.

Various methods to eliminate this weed, such as off-season cultivation, prolonged grazing of volunteer growth between paddy seasons, and application of weedkillers, have proved only partially successful. Recent investigations in British Guiana (4), however, have shown that, by increasing the ploughing depth to a minimum of eight inches and ensuring complete inversion of the soil, red rice may be almost completely eradicated. It cannot be assumed, however, that this method will be equally successful elsewhere for in some areas deep ploughing would have a most adverse effect on the soil and paddy crop.

One aspect of the problem appears to have escaped attention. Most types of red rice mature 10 to 14 days before the commercial varieties amongst which they grow. This fact may provide a key to the solution of the problem,

[1] 1 quintal = 100 kg.



Stem borers are the most consistently serious insect pest of paddy. Here a larva of Schoenobius incertellus *is shown in a damaged rice stem.*

for if varieties at present cultivated were replaced by others with a maturation period shorter than that of red rice, the latter would presumably be denied an opportunity to mature.

Stem Borers (5). Stem borers are the most consistently serious pest wherever paddy is grown. They cannot be eliminated during the off-season because their high productive rate makes it possible for them to increase out of all proportion to their initial population. Furthermore, owing to their long larval emergence period, and the number of generations in a year, several insecticidal applications are necessary to obtain a measure of control—and this may prove uneconomic.

Many attempts have been made to control stem borers with chlorinated hydrocarbons and organo-phosphorus insecticides, but it cannot be claimed that a sound basis of control has been found which is suitable for general application. Despite the many difficulties and in face of many discouraging results, Parathion, EPN, DDT, BHC, endrin and dieldrin have all proved effective under certain conditions, but because the number of generations of stem borer varies from country to country and the effectiveness of the insecticides depends largely on correct timing of application, it is impossible to recommend a single method of treatment for general use.

Hoja Blanca. This disease has attracted more attention in recent years than any other malady of paddy. It was first observed in Panama in 1952; in the subsequent six years it appeared in Cuba, Venezuela, Costa Rica, Columbia and Florida. Recently it has been reported from Surinam, Louisiana and British Honduras. In many instances the disease has caused considerable loss of the paddy crop.

Hoja blanca resembles stripe disease of paddy. The symptoms include yellowish-white discoloration or streaking of leaves and the most severely affected plants may fail to head.

It has now been ascertained that it is a virus disease, transmitted by the plant hopper *Sogata orizicola.* Treatment consists of spraying affected fields several times with insecticide to prevent further spread of the disease by the insect vector (1).

Investigations in the United States have shown that a great number of strains and varieties of paddy are resistant to the disease. Some of the resistant varieties are held in reserve in each State for general release should an outbreak of *Hoja blanca* appear in any of the main rice-growing areas (6).

* * *

The above notes on developments in the rice industry are selected from an extensive literature on the subject. They touch on widely differing problems and demonstrate the apparently unique nature of individual rice-growing regions. Hitherto, time and effort have been spent on conducting rather haphazard experiments in rice-producing areas. The object of FAO, as we see it, is firstly, to obtain agreement of producing countries on fundamental investigations and secondly, to correlate the results of regional experiments. The co-ordinated results may well explain the varying reactions observed in different countries and lead to a more rational application of science in agriculture.

REFERENCES

1. Dopson, R. N. *Hoja blanca* program in Louisiana. *Rice J.* **63**, 1, 21, 1960.
2. Dudal, R. Paddy soils. International Rice Comm. *Newsletter* **7**, 2, 1958.
3. Dumont, R. *Hunger and Food* pub. by World Federation of Scientific Workers, 1958.
4. Giglioli, E. G. Mechanised rice cultivation at the Mahaicony Abary Scheme, British Guiana. *Trop. Agric.* (Trin.), **36**, 1, 10-11, 1959.
5. Jepson, W. F. *A critical review of the world literature on the Lepidopterous stalk borers of tropical crops.* Commonwealth Inst. of Ent., 1954.
6. Lewis, R. D. New varieties open new horizons for U.S. rice. *Rice J.* **62**, 9, 14, 1959.

Steps towards Wheat and Barley Improvement in the Near East

by **J. B. Harrington,** Ph.D. *FAO, Rome.*

The Near East Region is as large as Europe, including European Russia; it extends 6,000km. from east to west and averages 1,500km. from north to south.[1] It is the original home of wheat and barley, which have been produced there for thousands of years. These crops, admirably adapted to the region, occupy a third of the arable land, provide four-fifths of the total food grains and furnish half of the calorie and protein requirements of the 130 millon people who live there. Of these two cereals wheat is by far the more important, being the basic food of all the people of this vast region. Barley, on the other hand, is a basic food for livestock in most of the countries.

The people of the Near East use their wheat to make flat unleavened bread, which is their principal diet. It is, in fact, almost the only food of the vast majority. Not only is the diet monotonous but most of the people have insufficient bread to satisfy their hunger, as crop yields are both low and uncertain. This is a situation that has cried out for attention, especially with the rapid rate of population growth in the region, as elsewhere in the world, and it was some eight years ago that action was taken to improve it.

In 1952 the recognition of various important factors resulting in low yields led the Governments of the region to seek technical assistance for wheat improvement. These factors were: lack of good seedbed preparation, slow and inefficient methods of tillage and seeding, too little use of chemical fertilisers, inefficient use of irrigation water, the use of varieties lacking rust resistance and straw strength, and lack of mechanisation in dryland farming.

In 1953 the countries concerned requested FAO to provide a regional consultant and in the autumn of 1955 the present author, a cereal breeder from the western plains of Canada, was assigned to the task. He has made two complete tours of the Near East each year since then. He advises officials on matters relating to such questions as the size of their wheat and barley improvement programme, fellowships for training technical officers, and facilities and equipment needed. He spends much of the time in the wheat breeding nurseries and plots with the breeders and other scientists associated with them on wheat improvement and production.

Each country cooperates by growing and testing the many new varieties of wheat introduced by FAO each year from countries with advanced wheat breeding programmes. Testing, variety trials and seed propagation are the

[1]The FAO wheat and barley programme for the Near East at present includes Afghanistan, Cyprus, Iran, Iraq, Jordan, Libya, West Pakistan, Turkey and the United Arab Republic.

This bearded wheat, a US variety, Baart 46, yielded well above the standard in both grain and straw when grown in irrigated trials at Sidi Mesri Experimental Station, Libya.

essential features of a programme for increasing wheat production by breeding, which is carried out on a co-operative basis by countries in the region. Seminars for training young agronomists have been arranged and breeding material is exchanged between the cooperating countries.

At the same time considerable help has been given by the United States Government and other agencies in the training of personnel and the providing of greenhouses, plant breeding equipment and technical assistance to individual countries.

In recent years tremendous increases in cereal production have been achieved elsewhere in the world. One striking example is Mexico, which is similar to much of the Near East region in latitude and climate. The yield of wheat 23 years ago in Mexico averaged only 8.6 quintals[1] per hectare compared with 10.2q/ha. for the Near East. In 1943 Mexico secured the assistance of Dr. N. E. Borlaug, a wheat pathologist/breeder of the Rockefeller Foundation, and in 16 years has almost doubled the yield per hectare bringing it up to 14.3q/ha. During the same period the yield in the Near East rose to 11.0q/ha., or a rise of only 8 per cent. compared with the 87 per cent. increase in Mexico. Now Mexico has so much wheat that the area used for that crop is being reduced.

Experts are convinced that a spectacular increase in wheat production can be obtained in the Near East in a very few years if a forceful modern programme of improvement and production is carried out. A 10 per cent. increase, equivalent to 1,600,000 tons and worth about $100 million, will give sufficient food for the present. A 50 per cent. increase, which it is quite possible to attain, would allow the area in wheat to be reduced and the released land to be put into vegetables and forage crops with resulting increases in dairy products and a higher standard of living.

It is estimated that a vigorous regional programme under the Freedom from Hunger Campaign that has recently been launched by FAO, and costing less than $2 million, will increase wheat production in the Near East by 20 to 25 per cent. in the next five years. This requires additional technical assistance, and many fellowships and certain facilities and equipment, some of which will be provided by the Governments in the region. A similar increase can be achieved in barley production for which essentially the same procedures are used.

[1] 1 quintal = 100Kg.

Fertilisers and Food in Asia and the Far East

by **P. Allan,** *Shell International Chemical Company.*

In a short review, space does not allow of a lengthy exposition on the nutrient needs of individual crops and soils. Perhaps all that need be said here is that most crops require adequate supplies of at least 12 elements for satisfactory growth. Generally speaking, most of these are only required in very small amounts and are present in adequate quantity in most soils. By contrast, the important major elements, nitrogen, phosphate and potash, are not generally present in cultivated soils in sufficient amounts to provide for the optimum needs of plants. The supply of these elements which is naturally present in the soil therefore has to be supplemented from outside, and it is the need to produce these extra supplies which has led to the establishment of the fertiliser industry.

Adequate fertiliser use is, without any doubt, the one practice which will most effectively and most rapidly raise the level of the world's food supplies. Naturally, if fertilisers are to have their full effect, certain other factors must be operating at a satisfactory level: for example, adequate water must be available, a certain minimum of cultivation must be carried out, pests and diseases must be controlled, and so on. Given these suitable conditions, the record of practical experience in the advanced agricultures of Western Europe, the US and Japan, and much experimental work in other areas, support the assertion of the predominant importance of fertilisers.

As an indication of the magnitude of the effect of fertilisers in increasing crop yields, the examples given in Table I are illuminating. They must, of course, be taken as broad averages only, for, as between one area and another, there will be great differences in soil composition, structure and nutrient content, water supply, crop variety, cultural methods and so on, which will affect the yield increase in any particular case. Moreover, although the indication that nitrogen has a much greater individual effect than either phosphate or potash is, generally speaking, true, the nitrogen figures would not be so high if there had not also been given an adequate basal dressing of the other nutrients. With few exceptions, a complete fertilising with all three of the major nutrients is desirable.

Further illustration of the importance of fertilisers is provided by Table 2, which compares average crop yields and degree of fertiliser usage in a range of countries.

Tables 2 and 3 draw attention to another aspect of fertiliser use in different parts of the world, namely the relative importance attached to nitrogen, phosphate and potash in the high-consuming countries of Western Europe, Japan and Taiwan on the one hand, and the low-consuming

Table 1

Effect of fertilisers on crop yields

Crop	*Country*	*Average additional yield (in pounds) per pound of nutrient supplied*		
		N	P_2O_5	K_2O
Rice (Paddy)	India	13½	6½	5½
	Taiwan	11—13½	2½	2
	China (Pre-War)	10½	5	¾
	Thailand	10	1½	0
Wheat	India	11	5	—
	Taiwan	5½—8	4—6½	8½—13
	UK (Hybrid 46)	19½	—	—
	(Other varieties)	12½	1	9
Barley	India	10½	9	—
	UK (New varieties)	23	—	—
	(Other varieties)	14	2½	1½
Maize	India	9	6	—
Sugar Cane	Taiwan (Sugar)	20½—21½	3	10
	Australia (Sugar)			
	(Plant cane)	12½	19½	7
	(1st Ratoon)	33	18½	6½
	India (Cane)	215	68	14

Table 2

Crop yields and fertiliser usage in selected countries

Country	*Crop Yields (100Kg/ha.) (averages 1948-1957)*				*Fertiliser Usage (Kg plant nutrient per/ha. agricultural land)*			
	Wheat	Rice	Maize	Potatoes	N	P	K	Total
India	7.2	12.3	7.4	65	1.6	0.3	0.1	2.0
Pakistan	7.8	13.8	10.4	76	1.6	0.1	—	1.7
Thailand	—	14.4	12.4	—	0.8	0.4	0.1	1.3
Burma	3.0	15.0	4.5	—	0.2	—	—	0.2
Ceylon	—	13.7	4.9	—	17.1	7.2	26.3	50.6
Indonesia	—	16.8	9.0	—	1.2	0.5	0.2	1.9
Malaya	—	20.5	—	—	7.2	9.0	1.8	18.0
Philippines	—	12.0	5.7	30	4.1	1.1	0.3	5.5
Japan	20.3	42.8	17.8	137	127	67	79	273
Taiwan	16.8	26.6	12.2	60	137	40	32	209
Australia	8.3	—	17.8	—	0.1	1.3	0.1	1.5
Holland	37.8	—	32.2	193	90	48	66	204
UK	30.9	—	—	188	25	30	27	82

areas of Asia on the other. The proportions in which these nutrients are used in the various regions are shown in Table 3.

Table 3

Relative usage of nitrogen, phosphate and potash

	Nitrogen	*Phosphate*	*Potash*
Western Europe ..	1.00	1.26	1.19
Japan	1.00	0.57	0.81
Taiwan	1.00	0.35	0.31
Low-consuming countries of Asia ..	1.00	0.30	0.15

There are a number of reasons why, so far, usage of phosphates and potash has, in the low-consuming countries of Asia, lagged so far behind that of nitrogen, low even as that is in quantitative terms.

First, nitrogen is the nutrient with the greatest yield increasing effect. Second, its effect on the appearance of the crop is much more quickly and readily apparent than applications of phosphate or potash; this is a point of some practical importance where one is dealing with less advanced agricultural communities. Third, there are many important soils and soil groups in Asia where, while nitrogen is always deficient, phosphate and potash may be reasonably, if not entirely, adequately present in the natural soil reserves. Fourth, the most important food crop of the area, rice, appears to have a particular requirement for nitrogen.

In the long term, usage of phosphates and potash will have to approach more nearly the ratios common in Japan and Western Europe if the greatest possible amount of food is to be provided from local resources. Furthermore, use of all three must be complemented by greater employment of the other practices earlier noted (for example, use of improved seed, a greater degree of irrigation, etc.). In countries with limited resources of capital and trained teaching personnel, and with a backward agricultural population, progress towards optimum employment of all these practices cannot, however, be expected to be rapid. It cannot be denied that the most sensible first step is to encourage a greater use of nitrogen, as is now being done with such great practical success in India and Pakistan.

FERTILISER SUPPLY AND DEMAND

Turn now to the world supply and demand picture, as it is at present and as it may be in the future, and relate it particularly to the situation in Asia and the Far East. The

three nutrient elements to be considered can most conveniently be taken in order of increasing importance so far as these regions are concerned: potash, phosphates and nitrogen.

Potash

Of the present world production of 7.75 million tons (as K_2O), of potash fertiliser, none (beyond a few hundred tons in India) is produced in Asia. France, Germany, the US, Canada, Spain, Israel and Russia are virtually the only supply sources. Asia (which here excludes Russia) accounts for only 7 per cent. of the world consumption and Japan alone takes seven-tenths of this. Oceania's proportion of the world total is 1 per cent.

Up to the present, potash has not been shown to be as important a nutrient in the tropics as it is for temperate climate soils and crops. It may, however, become of greater significance as more experimental work is carried out. From Table 4, in which is set out a forecast of likely future needs, it would seem that Asia and the Far East (including China) might well be using 70 per cent. more potash in 10 years from now. Usage at a level closer to the optimum might well bring demand to a level two and a half times greater than that of today. Similar increases for Oceania might be two and a half and five times respectively. Japan will continue to be the biggest user, both actually and proportionately to arable area, but China, India and Australia are likely to show an increasingly important demand.

There will be no shortage of supply, in view of the huge reserves yet to be exploited in Canada, Russia and elsewhere. Unless worthwhile deposits are discovered locally, which at the moment appears unlikely, all supplies for Asia must continue to be imported.

Phosphates

World production of phosphates for fertiliser use is nine million tons (as P_2O_5), all except about half a million tons of which is processed (i.e., to superphosphates or recovered as basic slag) before use. Of the total processed, Asia (excluding Russia) accounts for only 6 per cent.; Oceania's proportion is between 7 and 8 per cent.

Asia and Oceania hold similar shares of the world's consumption of fertiliser phosphates. In Asia, apart from

Table 4

Present use and forecast future needs of fertilisers in Asia and the Far East

	Nitrogen				Phosphate				Potash			
	Present Consumption	*Present Production*	*Target or Forecast of use 1968/70*	*Forecast long-term Needs*	*Present Consumption*	*Present Production*	*Target or Forecast of use 1968/70*	*Forecast long-term Needs*	*Present Consumption*	*Present Production*	*Target or Forecast of use 1968/70*	*Forecast long-term Needs*
	Thousands Tons Plant Nutrient											
Pakistan ..	40	10	150	300	3	1	50	150	Nil	Nil	Included with Phosphate	
India ..	260	82	1000	2500	40	40	450	1000	13	1	ditto	ditto
Ceylon ..	26	Nil	80	120*	11	Nil	30*	50*	40	Nil	60*	80*
Burma ..	2	Nil	10*	20*	Nil	Nil	?	?	Nil	Nil	?	?
Thailand ..	6	Nil	10*	70	3	Nil	6*	70	1	Nil	2*	8
Malaya ..	16	Nil	24*	50*	20	Nil	25*	40*	4	Nil	8*	15*
Indonesia ..	22	Nil	35*	75—150	8	Nil	16*	50	3	Nil	6*	12*
Philippines ..	30	6	50	80*	8	5	20	35—45*	2	Nil	15	20*
Japan ..	640	880	660*	680*	340	370	380*	400*	400	Nil	420*	450*
Viet-Nam, Laos Cambodia	8	Nil	?	?	18	Nil	?	?	2	Nil	?	?
China ..	500	170	1000	4000	75?	60?	400	800	5?	Nil	?	250
Taiwan ..	120	70	120	140*	35	24	50*	60*	28	Nil	40*	50*
Australia ..	34	25	70*	150*?	485	485	600*	700*	36	Nil	80*	160*
New Zealand	6	2	10*	20*	235	235	280*	350*	20	Nil	60	95

*Author's forecasts. Figures not marked with an asterisk are official Government targets or targets recommended by official advisers.

Maize: the two outside plots were treated with fertiliser, the centre plot was not.

Contrast between fertilised and unfertilised millo.

Japan, phosphates are still relatively little used, although it is known that in many areas, notably Indonesia, the soils are deficient in this element. One reason for the low rate of usage certainly lies in the fact that rice, Asia's most important crop, generally shows little response to phosphate additions. Oceania, in contrast to Asia and, for that matter, the rest of the world, uses huge amounts of phosphates in relation to nitrogen and potash. This is because of the specialised systems of pasture management developed under the specific soil and climatic conditions found in Australia and New Zealand.

The outlook for phosphate usage in Asia is for it to double in volume over the next 10 years and quadruple in the long term. In Oceania advances will probably be of a lower order of 20 per cent. and 45-50 per cent. respectively, because present usage is already at such a high level. Japan, Australia and New Zealand will continue to satisfy their own requirements of processed phosphates, i.e., by conversion of imported rock phosphate to superphosphate. India is certainly aiming eventually to become self-sufficient (again, using imported raw material), as probably also are China and Taiwan. The majority of the other countries would seem likely to continue to import their modest requirements either as ground rock or processed materials. Europe and Japan should be the main supply sources.

Nitrogen

World nitrogen production exceeds 10 million tons, of which 85 per cent. is destined for fertiliser use. Of the total, Asia produces some 13 per cent. and Oceania much less than 1 per cent. Of Asia's 13 per cent., Japan produces 9 per cent., China 1½ per cent., India and Taiwan not quite 1 per cent. each, and the remainder comes from the small outputs of Pakistan, the Philippines and South Korea.

Oceania's consumption of nitrogen is as low as its production; but Asia is a large importer, its consumption being one-third higher than its production; Asia accounts, in fact, for one-fifth of all nitrogen consumed in the world. It has, however, to be noted that heavy production, consumption and export in Japan distorts the overall Asian picture somewhat. If Japan is excluded, it is seen (Table 4) that the rest of Asia consumes three times more nitrogen than it produces, the actual figures being of the order of one million tons and 0.34 million tons respectively. The deficit is made up by imports from Japan, Western Europe and, to a relatively small extent, the US.

What is the Asian demand for nitrogen in the future likely to be? If the plans and intentions of the Governments of the countries concerned all become realities, demand 10 years from now could be double what it is to-day or, in actual figures, over three million tons of nitrogen. The longer-term forecast, i.e., when usage is getting closer to the level required for optimum production of crops, is for a utilisation five times that at present, or over eight million tons. Table 4 shows how large a part the needs of China and India play in these potential demand figures.

Spraying citrus trees against scale in Venezuel

More food by crop protection

by **George Ordish.**

Whenever a plant is growing abundantly there are found those other forms of life which need that plant as food, in other words the bacteria, viruses, fungi, insects, birds, mammals and so forth which we know under the collective name of pests. And man is found there too, for, in the last analysis, he is the worst pest of plants.

That crops are attacked by pests is one of the fundamentals of the pattern of evolution, and they always have been so attacked: it is no modern innovation but merely means that the life-forms feeding off the crop plant are seeking their food as best they can, and as man tries to prevent them getting it by various methods, then adapting themselves to the new conditions and attacking again. One of the best ways of increasing food production is to prevent this loss of crop to other forms of life and preserve it for man, ever the whole object of farming.

Crop losses from pests are already high: even where steps are taken against them there is still a loss, for the measures used are not perfect and to this residue of loss must be added the cost of the measures themselves. Where steps are not taken against pests, as in many underdeveloped agricultures, the losses can be considerable. In many cases desirable crops or varieties are not grown because they are too susceptible to these troubles.

Losses from pests and diseases have been the subject of a few economic studies and more are needed. WATTS PADWICK (5) has summarised some data for diseases in the present and former British Colonies: for instance, swollen shoot of cacao in British West Africa by 1953 represented a capital loss of £25 million, with an annual loss of 80,000 tons of cacao. MORSTATT (3) considers a number of losses during the inter-war years, running from 5 per cent. to 25 per cent. Recently, A. H. STRICKLAND (6) has summarised some of the available figures for particular pests, quoting, for instance, a loss of 5 per cent. from Senn bug in wheat in Turkey; a loss of a ton per acre from potato blight in Britain, to which must be added an additional $1\frac{1}{2}$ per cent. loss from wireworm and slugs; in Italy, a loss of lemons of 15-20 per cent. from attack by citrus bud mite; and in the USA 15 per cent. losses of the cotton crop due to insects.

A recent study from Burmah-Shell (1) on India has a number of illuminating points in this field to which I shall refer in detail later in this article. The crude figures show staggering crop losses from insect pests in India of the value of £273 million per annum. It should be noted, however, that no notice is taken of price elasticity or market need in this figure (see reference No. 4) on the one hand, or of crop diseases on the other.

Crop Protection Measures

Losses from pest attack can be overcome in a number of ways which fall into three main categories—mechanical, biological and chemical. The mechanical methods are the use of rotations, special planting or harvesting dates to avoid a pest, and so forth, or the ultimate sanction—not growing the crop: this is what the economist calls the 'sacrificed opportunity', an event quite common in underdeveloped agricultures where frequently certain crops, or high yielding varieties, cannot be grown because of pests.

Biological methods include the use of immune and resistant varieties, or of parasitic or predaceous insects;

where they exist, or can be found, they are very cheap. For instance the introduction of a Tachnid parasite to control the coconut moth in Fiji cost some £22,000 and saved crops worth £300,000 yearly from extinction, and the condition has now persisted for 25 years (4). However, in most cases such methods simply are not available. Side effects can also be noted: for example the breeding of special wheats immune to rust has led to the establishment of exceptionally virulent strains, such as the 15B, for the fungus can in effect breed more quickly than man can produce new wheats.

Chemical methods hardly need any description; they are the use of sprays, dusts, fumigants and so on. In the same way that resistant varieties may lead to virulent strains of disease, so too can the use of a pesticide lead to resistant races of pests: the moral is that we must continually be alert to the evolutionary changes going on around us and be ready to adapt our control systems to changed circumstances. We should use that method, or combination of methods, that will give us the best economic advantage in our inevitable struggle with pests.

Crop Protection Economics

To be worth the farmer's while the cost of protecting a crop must obviously be less than the benefit the method used brings. A ratio between cost and benefit can be established; thus in the case of the coconut moth in Fiji quoted above, the cost was £22,000 and the benefit £300,000, a ratio of 1:13.6, though the final figure can be multiplied by 25, the present life of the system, to give a ratio of 1:340.

Turning to the Burmah-Shell study of India (1) we find that insect pests prevent the production of rice worth Rs.27.41 crores[1] and that this could be prevented by the use of insecticides (aldrin, dieldrin and endrin) worth Rs.2.18 crores allowing the same sum for costs of application we get extra rice worth 27.41 crores (some 563,000 tons) for an expenditure of 4.36 crores, a ratio of 1:6.5.

There is a wide range of such ratios in this field: in some cases they are less than unity, which shows that the method does not pay, but in general ratios of 1:4 to 1:8 are quite common for chemical control.

Fertiliser Application and Crop Protection Compared

Whilst it is of course possible to compare the ratios of cost to benefit given by the use of fertilisers with those given by the use of pesticides (or of any other method of improving output), such a comparison is only justifiable when it is borne in mind that the crop must first be grown, which usually means using fertiliser, and that it can only be protected from pests if there is a pest attack.

Table 1 gives a few ratios for fertiliser calculated from the response figures recorded by IGNATIEFF and PAGE (2). In general the cost/potential benefit ratios for crop protection are higher than those for fertiliser, but this does not mean that crop protection can be substituted for fertiliser, but that it compliments it.

The benefits to be obtained from a fertiliser application are more general and widespread than from the use of crop protection methods. There are some places and soils where there is no economic response to fertiliser, but they are not numerous. When crop protection can be used it usually gives cost/benefit ratios in excess of fertiliser ratios. Pests may only attack from time to time (e.g., locusts), or the intensity of outbreak may vary from year to year, whereas if a fertiliser response is obtainable it can be got every year there is enough water.

In high yield agriculture the one complements the other, for where crops increase the net loss from pests increases, even if the percentage attack remains the same. It is obvious that a loss of, say, 10 per cent. on the average Netherlands grain return of 3,400Kg. per hectare (FAO) is a considerably greater net loss per hectare than 10 per cent. of the Indian average yield of 700Kg. per hectare.

When 'two blades of grass grow where one grew before' (7) it is obvious that any insect or fungus desiring a blade

[1]1R. crore equals 10,000,000 rupees, equals £750,000

Table 1
Returns to fertiliser usage

Country	*Crop*	*Fertiliser (NPK)*		*Value*		*Ratio cost (unity)/benefit*
		Kg per ha.	*Cost*	*Crop*	*Extra crop*	
UK	Potatoes	952	£17		£86	1:5.06
		1,904	£34		£114	1:3.35
Senegal	Groundnuts		frs. CFA	frs. CFA	frs. CFA	
		nil		16,000		
	(a)	150	3,000	20,000	4,000	1:1.33
	(b)	150	3,000	22,400	6,400	1:2.13
Senegal	Millet	nil		12,000		
	(a)	100	2,000	16,800	4,800	1:2.4
	(b)	100	2,000	19,200	7,200	1:3.6
Madagascar	Cassava	30 tons farm manure	6,000		9,000	1:1.33
		100Kg. KCl*	1,500		40,000	1:26.6

*(an exceptional response due to a potash deficient soil)

Banana plants being sprayed against leaf spot disease in Venezuela.

Cabbages being sprayed with Phosdrin for aphid control in the UK.

of grass will have double the opportunity of acquiring it. The same increased opportunity occurs wherever a host (plant or animal) becomes more numerous, hence the importance of protecting the bigger crops brought about by improved methods—fertilisers, better varieties, irrigation, rotations and so forth. Big yields per acre are usually the easiest way of increasing production.

India. The Burmah-Shell Study

These points are well illustrated in the study mentioned above, which has served as a basis for Table 2. In this table the headings to columns 1, 2, 3 and 4 are self-explanatory. The figures in column 5 represent the value of the crop which could be saved by the application of aldrin, dieldrin and endrin (the tonnages which, I estimate from the study, would be necessary for this are given in the text below). Column 6 shows the cost of the insecticides needed to save the crop values given in column 5. Column 7 shows the ratio, cost: potential benefit, cost being given as unity. The cost of using pesticides is not only the cost of the pesticide, but also the machines needed to apply them and the financing of supplies: this figure is of the same order as the cost of the pesticides themselves; consequently, column 7 is $\frac{\text{col. 5}}{\text{col. 6}\times 2}$.

From the table it will be seen that some remarkable increases could be obtained by better crop protection. There is the return of six-and-a-half times the investment in insecticides and their application in the case of rice, and even greater figures are found for some of the other crops considered.

The overall figures are: losses of crops worth Rs.484.18 crores (£360 million) occur; there is a possibility of saving crops worth Rs.92 crores (£69 million) by an expenditure of Rs.9.8 crores (£7.3 million) for pesticides and application: this is a return of 9.4 times the money invested. One can calculate from this study that such a campaign would need nearly 2,400 tons (short) of endrin, 1,900 tons of aldrin and nearly 300 tons of dieldrin.

The above are by no means the only increases of production obtainable by crop protection, but they are significant indications of the returns possible from investment in this field. Pesticides and other forms of crop protection can play an important part in raising production under the Freedom from Hunger Campaign: the world cannot really afford to let so much food go to feed pests.

REFERENCES

1. Burmah-Shell. *Agricultural Production in India and Estimated Losses due to Pest Damage*. Bombay, 1960.
2. Ignatieff, V. and Page, H. J. *Efficient Use of Fertilisers*. 2nd. edn. FAO, Rome, 1958.
3. Morstatt, H. *Handbuch der Pflanzenkrankheiten*. Vol. 6. Parez, Berlin and Hamburg, 1952.
4. Ordish, G. *Untaken Harvest*. Constable, London, 1952.
5. Padwick, G. Watts. Losses caused by plant diseases in the colonies. *Phytopathological papers*, No. 1. Commonwealth Mycological Institute, Kwe, 1956.
6. Strickland, A. H.. Pest and disease losses in agriculture. *New Scientist*, **8**, 199, p. 660, 1960.
7. Swift, J. *Voyage to Laputa*. 1725.

Erratum

Table 2

Losses from pests and returns to use of insecticides, India

1	2	3	4	5	6	7
Crop and pests	*Total Area '000 acres*	*Crop Lost*		*Value of crop to be saved by treatment Rs. crores*	*Cost of chemicals to reduce loss Rs. crores*	*Ratio cost protection*
		'000 tons	*value Rs. crores*			
Rice						
Swarming caterpillar		562.84				
Stem borer		562.84				
Caseworm		562.84				
Rice bug		562.84				
Grasshopper		281.42				
Rice hispa		281.42				
	78,174	2,814.20	137.05	27.41	2.18	1 : 12.6
Other cereals						
Grasshopper, termites, cutworms, hairy caterpillar, stem borer, army worm	137,468	2,037.63	112.47	11.25	1.55	1 : 7.3
Pulses (including gram)						
Red hairy caterpillar, pod borer Gram caterpillar, cutworm	57,295	571.75	44.94	4.49	0.78	1 : 5.8
Potatoes (1954-5)						
Jassid, aphid, cutworm, white grub ..	665	88.10	2.90	0.29	0.03	1 : 9.7
Sugarcane		(raw sugar)				
Pyrilla, borer, termites	5,019	1,079.20	52.98	26.49	1.90	1 : 13.9
Tobacco						
Caterpillar, stem borer, aphid, cutworm ..	1,022	15.30	1.63	0.49	0.07	1 : 7.0
Groundnuts						
Hairy caterpillar, termites	13,101	204.30	13.24	2.65	0.37	1 : 7.2
Other oilseeds (including mustard, castor, sesamum and linseed)						
Aphid, hairy caterpillar, semi-looper, capsule borer, leaf and pod caterpillar	16,805	97.30	7.40	0.74	0.18	1 : 4.1
Jute						
Semi-looper, hairy caterpillar, jute apion ..	1,883	211.05	3.90	0.78	0.06	1 : 13.0
Cotton		(bales '000)				
Bollworm		472.3				
Jassid		188.92				
Leaf roller, stem borer, aphid, whitefly ..		188.92				
	19,843	850.14	29.17	5.83	1.22	1 : 4.8
Tea						
Mosquito, looper, thrips, leaf eater, aphid, termites	791	16.88	6.28	3.14	0.32	1 : 9.8
Coffee						
Green bug, borer, mealy bug, cutworm ..	232	2.22	1.03	0.56	0.06	1 : 9.3
Coconut		(millions of nuts)				
Black headed caterpillar, red palm weevil, Rhinocerus beetle	1,577	192.75	4.82	0.49	0.03	1 : 16.3
Chillies (dry)						
Thrips	1,450	35.40	4.81	1.44	0.09	1 : 16.0
Pepper (black)						
Mealy bug, flea beetle	234	1.60	0.36	0.04	0.001	1 : 40.0
Miscellaneous crops, fruit and vegetables						
Aphid, caterpillar, borer, grasshopper, termites, cutworm, bugs, fruit fly, thrips ..	125,000	1,500	61.20	6.12	0.94	1 : 6.5
TOTAL	460,559		484.18	92.21	9.78	1 : 9.4

Food lost in store by insect attack

by **G. V. B. Herford,** *Pest Infestation Laboratory, Slough.*

Everyone is aware of the need to increase the world's food supplies, and very great efforts are being made, on an international scale, to bring new land under cultivation and, by improving the efficiency of agricultural techniques, to produce ever bigger and better harvests.

By contrast, surprisingly little attention is given to the no less vital problem of preserving the harvested crops from insect attack while in storage. This may be because the growing crop has traditionally received the close attention of agronomists, geneticists, plant pathologists, entomologists and the like, whereas the harvested foodstuff becomes a 'commodity', and as such tends to be the concern of economists and industrialists.

The fact remains that very serious damage can be caused to harvested crops in store by the depredations of insects and mites. A very wide range of stored products is susceptible to infestation but those in which perhaps the most significant losses occur are cereals and cereal products of all descriptions, oilseeds, dried fruit, cocoa and tobacco.

While it is true that all of these crops are liable to insect attack in the growing stage, the types of insects by which the plants are attacked are in large part specific to a particular crop, or at least to a closely allied group of crops.

Stored product pests, on the other hand, are far more catholic in their tastes and many species regularly infest a wide range of materials. For example, the moth *Ephestia elutella*, though restricted to temperate countries, is a major pest of stored bulk wheat, tobacco and cocoa, and has also been recorded from a considerable number of other products. The Khapra beetle, *Trogoderma granarium*, is a very serious pest of cereals, especially in tropical and sub-tropical countries, and is also one of the most highly feared pests of harvested groundnuts, while one of the so-called flour beetles, *Tribolium castaneum*, will attack all types of cereals and cereal products, groundnuts and other oilseeds, cocoa, dried fruit, spices and legumes.

Many insects can survive for long periods in the small residues remaining in crevices and on ledges of warehouses and ships' holds after foodstuffs have been stored or conveyed. This, coupled with the cosmopolitan distribution and catholicity of taste of many of the pests, introduces serious hazards of cross infestation from one commodity to another and of reinfestation of clean commodities from infested ships or buildings, and underlines the need for constant vigilance at every stage, from the production of the raw materials to the manufacture of the finished product.

Much can be done to prevent or minimise insect damage by good storage hygiene, but once an infestation is thoroughly established, whether in a commodity or in storage premises, chemical control measures are necessary.

The number of chemical insecticides that can safely be used on stored foodstuffs is necessarily more restricted than those which can be applied to growing crops, for there is no opportunity, as in the agricultural field, for a poisonous insecticide to decompose or be washed off before harvest. Great care has therefore to be taken in the selection of appropriate chemicals to ensure that any residues left on

Experimental treatment of groundnuts with an insecticidal dust in West Africa.

Preparing to fumigate a pyramid of bagged groundnuts with methyl bromide in West Africa.

Experimental control of the cocoa moth in a London warehouse: spraying the walls and ceiling with a contact insecticide.

(Photos: Pest Infestation Laboratory, Slough)

the foodstuff will not be harmful to the consumer, be he man or animal.

Losses in Store

It is never an easy matter to obtain an accurate assessment of insect damage, whether one is concerned with the growing plants or the harvested crops; nevertheless the following estimates give a good idea of the magnitude of the losses that result from insect attack on stored products.

FAO published (2) in 1946 an estimated annual loss of 5 per cent. of all harvested cereals, peas, beans and oilseeds, resulting from infestation by insects. Such a global estimate can only be a rough approximation, but more accurate data, based on observation or experimentation, suggest that the FAO figure was a conservative one.

Thus, a Working Party of the United Nations reported (4) that in six Latin American countries the average annual loss resulting from the infestation of stored cereals and pulses was as high as 35 per cent.

It is only to be expected that insect damage is more severe in hot climates, and particularly in countries which may not be alive to the need for pest control work in relation to food storage. Nevertheless, even in temperate and more highly organised countries, losses may also be considerable. Of the grain harvested in the Great Plains region of the United States, 10 per cent. has been said to have been lost during one season's storage, while maize grown in the Southern United States may lose up to 9 per cent. of its weight per month of storage, as a result of infestation (1).

Results of properly controlled experiments confirm these more general estimates. Work that was undertaken in the Congo, for example, showed that after one year's storage the loss of weight resulting from insect attack was, for sorghum 50 per cent., for beans 20 per cent. and for groundnuts 15 per cent. (3). In Sierra Leone an experimental stack of par-boiled paddy lost 25 per cent. of its weight during one year's storage.

These figures do not allow for the weight of insects and of insect frass. The weight loss of 25 per cent. of the paddy in Sierra Leone referred to above rose to 41 per cent. after the grain had been screened (3).

Similarly, 3,000 bags of maize, infested by the Khapra beetle (*Trogoderma granarium*) and stored for two years in Nyasaland showed an apparent weight loss of 7 per cent. which, after screening, rose to 14 per cent. (3).

'Hidden' Losses

The losses quoted above are calculated from measured loss of weight of the commodity over a period of storage. It must be remembered, however, that damage can also be incurred in other, less obvious ways. Certain insects, notably moth larvae, and mites that attack grain will only destroy the germ, leaving the endosperm intact. In a heavy infestation of this type every grain may have the germ removed; although this might represent a very small direct percentage loss of weight, the effect on the nutritional value or, with malting barley or seed grains, on the germinative capacity would be very much more serious.

Insect infestation of oilseeds, such as groundnuts, can also markedly increase the free fatty acid of the expressed oil, largely, it is considered, because the nuts are reduced by the insects into smaller particles, with a correspondingly greater surface area exposed to oxidation.

All these are examples of direct damage, for which it is often possible to assign a financial value.

Indirect damage

Indirect damage may be no less serious, an outstanding example being the spoilage of foodstuffs, especially grain, by high temperature resulting from insect infestation. It had long been known that grain would heat if stored at too high a moisture content, the causative factors being the high rate of respiration of the damp grain, and of the micro-organisms associated with it. It is now recognised that, even when grain is stored at a moisture content normally considered 'safe', it may become heated as a direct result of insect infestation. This is largely due to the fact that grain has a very low thermal conductivity, and the small amounts of heat generated by pockets of insects within the grain are not dissipated, but remain localised as hot spots. The increased temperature stimulates the insects to greater activity, with the resultant production of more heat, until the whole bulk may be affected and damaged.

Finally, the mere presence of insects may result in serious financial loss, especially when they occur in an expensive finished product such as confectionery or cigars.

Although serious losses of stored products still take place, it is encouraging to note that there is an awakening recognition of the importance of the problem on an international scale.

Thus there was held, in Southern Rhodesia in 1957, a 'Meeting of Specialists on Stored Food Products', convened by the Scientific Council for Africa South of the Sahara (CSA), and it is hoped that others will follow. In Europe, the European Plant Protection Organisation (EPPO) convened a Stored Products Working Party, which meets every few years and has a wide representation.

These specialist conferences provide unique opportunities for exchange of scientific and technical information, and for the formulation of appropriate 'codes of practice', and tolerance levels of infestation.

There is, however, no room for complacency, and much remains to be done in research, organisation and education before we can ensure that the world's crops, once harvested, can be safely kept for human consumption, without contributing their tithe to the insects.

REFERENCES

1. Cotton, R. T. *Pest Control* **18** (10), pp. 8 *et seq.* (1950).
2. FAO: Expert Committee (1946). *Destruction of Food in Storage by Insects, Mites, Rodents and Mold Fungi.* Nu/WaWP3. Washington, D.C.: Food and Agriculture Organisation of the United Nations (Mimeo.).
3. Scientific Council for Africa South of the Sahara, *Report on Meeting of Specialists on Stored Food Products*, publication No. 31, 200 pp. (1958).
4. United Nations, Dept. Econ. Affairs, II, G.1., pp. 65-6, Washington, D.C. (1950).

The need for

Efficient Extension Services

by **D. C. Kimmel,** Ph.D., *FAO, Rome.*

In the past 10 years considerable effort has been devoted to measures intended to show spectacular and quick results in increasing agricultural production. There have been tremendous expenditures on irrigation, mechanisation and other physical facilities. During this same period the term 'extension' has become popular and has been applied to various sorts of existing and newly created agricultural services. Efforts to orient and use these services for training and influencing farmers in general, and, in particular, to make good use of the improved physical facilities, have been relatively minor and ineffective. The purpose of this article is to explore some of the reasons for this lack of effectiveness.

The term agricultural extension, as employed in FAO, and as used here, refers to an informal out-of-school education service for training and influencing farmers to adopt improved practices in crop and livestock production, management, conservation and marketing. Concern is not only with teaching and securing adoption of a particular improved practice, but with changing the outlook of the farmer to the point where he will be receptive to, and on his own initiative continuously seek, means of improving his farm business and home. Extension is the only educational approach treated here as it is considered the most promising one for the vast areas of the world where the potential for increased agricultural production appears to be greatest.

Organisation for Extension

An inappropriate organisation is a common cause of ineffective extension work. The organisation for extension work cannot be considered apart from the overall organisation for agricultural development and, in particular, for certain complementary services. A farmer can be taught how to produce more and better crops but unless there is a source of supply and credit to purchase the improved seeds, insecticides or fertilisers recommended by the extension officer, nothing can happen. Where no provision is made for such tasks as distribution of seeds and fertilisers and the associated record keeping, collection of statistics and enforcement of laws, these tasks often fall to the extension service. As a result of his having to enforce the law, the so-called extension officer fails to gain the confidence of the cultivators, and because of his many other non-educational duties, he has little time for, or tends to neglect, his more difficult but more significant educational tasks.

Research is a most important complementary service requiring a strong link with extension. Although an extension service can make a beginning by passing the experience of the better to the less successful farmers, in the absence of a practically oriented research service it would soon cease to serve a useful purpose. Similarly, a research service without an extension service to carry its findings to, and bring back the actual problems of, the farmers, can contribute little.

One of the most significant organisational features of successful extension work is the vesting of administrative responsibility for all farm extension work in one service. In this system, only one extension officer works at the farm level. He looks at the problems of improving the farming operation as a whole, the way the farmer himself must view them. This system avoids such pitfalls of the multiple extension services approach as: (1) conflicting or contradictory advice which results in confusing the farmer, and possibly making him lose confidence in the government and its extension agent; (2) over-emphasis on one enterprise, perhaps not even an important one, to the neglect of others; (3) passing to the semi-literate or illiterate cultivator technical advice which he cannot understand; (4) excessive operational costs in terms of personnel and finance. It is to be emphasised that where the single extension officer is employed at the field level he must be supported at higher administrative levels by specialists in the various aspects of agriculture.

Selection and Training of Extension Personnel

A sound organisation can be effective only when its staff have been specially selected and trained to do educational work with farmers. All too often when an extension service is established, the misfits from other government departments are assigned to the new service. Frequently the officers so assigned have been previously engaged in law enforcement or the provision of direct services to farmers. Even with proper training it is difficult, if not impossible,

Students from a number of Far Eastern countries receiving forestry instruction at an FAO training centre in the Philippines.

Burmese veterinary students attend an anatomy class; they have completed a two-year course in intermediate science at Rangoon University.

to change their regal and paternalistic approach to the cultivator. It cannot be emphasised too strongly that a most significant step in the establishment of an extension service is the selection of the right personnel. Only men with a genuine feeling for the farmer and a willingness to live and work with him in his village and fields are likely to become successful extension officers.

An extension worker must be trained in technical subject matter and in how to teach and influence farmers to employ this subject matter. This latter training in the methodology of extension education, rural sociology and related social sciences is seldom included in the training courses for prospective or practising extension workers. Technical training is sometimes theoretical and unrelated to the actual farm problems faced by the extension worker. One way to ensure that technical training for extension workers is suitable is to develop it in association with applied agricultural experimental stations. General improvement in extension training awaits the development, in selected universities throughout the world, of facilities and staff for training the trainers of extension workers.

Budgetary Support for Extension

It is perhaps not mere coincidence that countries such as the Netherlands, Japan, Taiwan and the United States, where the much-discussed gap between research and its application on the farm is relatively narrow, have well financed and strong extension services. There are other countries where the value of an extension service, as reflected in budgetary provision for its operation, is little appreciated. For example, a recent study reveals that in some Asian countries, where up to 65 per cent. of national income was derived from agriculture, as little as 1.12 per cent. of the national budget went to the Ministry of Agriculture. The proportion of this small agriculture budget devoted to extension was less than 1 per cent.

Due to negligible budgetary provision, the numbers of extension workers, their salaries and working conditions are far from ideal. The number of extension workers required varies with size and type of farm, educational levels of farm populations, distance between farms and communication facilities, but on the average a ratio of one extension worker to 600 farm families might be considered a suitable goal. This level of staffing has been reached in few countries and the situation is further aggravated by the poor training and burden of non-educational duties of available staff. Salary levels for extension workers, and in ministries of agriculture generally, are much below what is paid in other ministries for comparable training and experience. It is obvious that one of the prerequisites of an effective extension service is a much higher priority in governmental development plans, and a reflection of that priority in expanded budgetary provisions.

FAO has organised conferences in the various regions of the world for senior officials of ministries of agriculture concerned with extension organisation and administration. Invariably, participants in these conferences have emphasised the need for a sound organisation, appropriate selection and training of personnel, and adequate government support as key elements in successful extension programmes. When, and only when, governments are prepared to take vigorous action along these lines, can farmers be expected to make a substantial contribution both to increasing the world food supply and to enhancing their own welfare.

BIBLIOGRAPHY

The following FAO reports on agricultural extension may be referred to:—

Present Status of Agricultural Extension. Development in Asia and the Far East. By C. W. Chang. Restricted draft, March, 1960.

Report on the Near East Regional Extension Development Centre, Beirut, Lebanon. 1953.

Report on the Agricultural Extension Development Centre for South America. Belo Horizonte, Brazil. 1959 (draft in press).

Report on the Agricultural Extension Study Tour for Asia and the Far East. Japan, the Philippines and India. 1958.

Report on the Agricultural Extension Development Centre for Asia and the Far East, Bhopal, India. December, 1955.

Report on the Agricultural Extension Training Centre for Asia and the Far East. The Philippines. 1958.

Report of the Near East Technical Meeting on Agricultural Extension. Teheran, Iran. October, 1958.

Report on the Agricultural Extension Development Centre for West Africa, Ibadan, Nigeria. July, 1959.

Food, Land and Manpower in Western Europe.
P. LAMARTINE YATES. Macmillan, London. 35s.

This is a book that ought to be consulted by all persons actively concerned with the development of agriculture in more than one country of Western Europe. This is because the author, in a relatively short book, has successfully combined:—

(1) Valuable comparative information, in statistical, graphical and comment form, on the food and agricultural production of each country;
(2) Important forecasts of developments in the next 10 years in the consumption and production of food; and
(3) Clearcut suggestions as to the kinds of national agricultural policies to be followed.

Yet this array of information and forecasts has been set in a matrix of a clearly written book which is warm with understanding of both the problems and the fascinations of the European countryside.

This book is the first in a series of four studies on European problems being prepared by the Twentieth Century Fund, an American research foundation. The author has had considerable experience as a research worker and administrator on food and agricultural problems, both with the British Government and, of later years, with FAO, and he is a well-known writer on such matters.

The publication is designed in five parts. The first sets the contemporary European scene and stresses that the problem in most western European countries is not so much a shortage of land for effective agricultural use as too many people engaged on its farms, with a relative scarcity of labour for expanding industrial development. The second part deals with food. It stresses the gap that has occurred between the simple and heavily carbohydrate diet of southern European countries and the more diversified diet of the northern countries with their greater consumption of livestock products, fats, vegetables, sugar and fruit. The nature of diets and the changes which are occurring are shown in detail for individual countries and commodities in statistical, graphical and commentary form. Pausing for a brief discussion of Governmental concern and action to integrate nutritional needs and agricultural policies, the author then proceeds to give important forecasts of the character and amounts of food likely to be consumed around 1970.

In the third part of the book, which deals with farming, the author's analyses of the availability of land and labour to agriculture in different countries and their productivity leads him on to suggest a target figure (close to the real situation in Denmark to-day) of $2,000 per male worker as a worthwhile aim in agricultural policy in Europe. He stresses that in order to reach this relatively high figure there will have to be a great reduction in the agricultural population of most European countries (excepting Great Britain) and big investment programmes—in agriculture in order to increase productivity per man, and in industry in order to provide more jobs for displaced agriculturalists.

This discussion is followed by a section devoted to the modernisation of agriculture. Existing farm structure and policies dealing with land consolidation, settlement and tenure are appraised and stress is laid on the twin needs of increased output per hectare and higher labour productivity on farms. Yields of most crops and of livestock are increasing relatively quickly in most countries except those bordering the Mediterranean, where there are difficult and unsolved technical problems. Improved productivity of labour is related to farm diversification, with increasing emphasis on livestock, mechanisation of farm processes and strengthening of research and extension services to agriculture. Here again, the author is bold enough to forecast the rate of growth of agricultural production (though not its national pattern) likely to occur in Europe up to 1970.

The section on Foreign Trade gives detailed statistics and description of food imports and exports by commodity and country, but it contains relatively little discussion or forecast. The book ends with a section on the way in which individual Governments have interfered and supported their own agricultural industries, and this leads on to a short but forceful set of suggestions on agricultural policy. Briefly, the author suggests that a more rapidly modernised family farm is perfectly well adapted to Europe's needs. In order to get faster increases in output per hectare and per beast, many countries need to alter the emphasis in their agricultural policy away from protection of the average or poorer farm to stimulation of the better ones. In the southern countries more fundamental research on technical problems, especially of grass and fodder-crops, is needed. If these and other things are done, Yates sees no reason why European farming should not, by 1970, be producing 30 per cent. more food with 20 per cent. less labour and at lower real costs.

G. P. WIBBERLEY.

Introduction to Plant Geography. NICHOLAS POLUNIN. Longmans, London. 60s.

It is just over a hundred years since the word 'ecology' was first coined by Haeckel, but it is only quite recently that the subject has begun to interest the general public, to be studied more intensely by the scientist, and its implications to be realised by the statesman—for ecological changes can have far reaching effects on our control of nature in the service of man, in a world under the threat of over-population.

It is for these reasons that this splendid, simple yet complete

book is to be welcomed. Professor Polunin is the leading authority on the subject of plant geography and his book is more than a mere introduction to the subject: it is a concise and clear account of the plant cover of the world and of the action and reaction of the various factors, of, for instance, not only geological formation on vegetation but also of the subsequent vegetation on geology.

That 'all flesh is grass' is well known today and the animal kingdom, including man, can only thrive as long as plants thrive, hence the importance of understanding the factors that lead to particular types and forms of plant cover, because the 'struggle for existence' is still with us. Man can only continue to exist in such large and increasing numbers (and comparative comfort) if he goes on dominating nature; that is, seeing that the right sorts of plants continue to grow in abundance. Nuclear warfare is not the only way of extinguishing man as a species: comparatively small ecological changes could do it as well—at least, they have removed species in the past, and do so today (the cedars from Bermuda are an example), and presumably man is not exempt from these laws. An understanding of plant geography is an essential item in this dominance and it will be much helped by this work.

Professor Polunin starts by explaining what plant geography is: then in order that the reader may grasp what is to follow he describes the various groups of plants, their reactions to various stimuli, their methods of dispersal and their evolution. This may be well known to the botanist, and consequently these chapters can be omitted by the student of the subject; nevertheless, they do have a geographical slant and are thus of interest to the botanist too. With this disposed of, the subject itself begins to unfold. We have the types and areas of natural distributions of plants, the effect of cropping, the importance of plants to man, the effects of environment, climate, fresh and salt water, plant adjustment, applications and so on.

Each chapter is followed by an interesting bibliography of books for further reading, if need be; but it is of books only, which means that certain important papers must be omitted, though this does enable the work to be of reasonable length. It is interesting to note the references to the early studies of Barton (1827), Hinds (1843) and Megen (1846), and the credit given to A. F. W. Schimper (1903, *Plant-geography upon a Physiological Basis*). Professor Polunin remarks that Schimper's book is still the great reference work on the subject, but that an up-to-date one in English is badly needed.

This book is well produced and illustrated: the only thing your reviewer found missing was some reference to the modern statistical approach; however, there is a reference to Raunkiaer's work and the book at present under review is described as an introduction. It is an exceptionally good one. GEORGE ORDISH.

Geomorphology. B. W. SPARKS. Longmans, London. 37s. 6d.

For nearly a quarter of a century the young science of geomorphology has been served in Britain almost by a single textbook—WOOLDRIDGE and MORGAN's *Physical Basis of Geography: An Outline of Geomorphology* (Longmans), first published in 1937 and of which a slightly revised edition appeared in 1959. In America O. D. VON ENGELN's *Geomorphology* appeared in 1942 and A. K. LOBECK's magnificent picture book, *Geomorphology*, in 1939, but for a concise yet comprehensive text we had to wait till 1954 for the appearance of W. D. THORNBURY's *Principles of Geomorphology*.

In Britain, 1959 saw the appearance of G. H. DURY's lively and provocative *The Face of the Earth* as a Pelican. The publication of a new full-scale work like the present is thus something of an event. Geomorphology is literally the study of the forms of the earth, or land forms, and Sparks uses what is now the commonly accepted definition, "essentially it is the study of the evolution of land forms, especially land forms produced by the processes of erosion" (p. 1).

A comparison with Wooldridge and Morgan is inevitable: both books are addressed primarily to the first-year university student; both cover the same ground; both have numerous little line drawings and a selection of photographs; both are designed to stimulate further reading and an appreciation of the many unsolved problems which await investigation.

It has been said that a student at Cambridge reading for the Geography tripos makes the subject for himself: he attends lecture courses which tend to cover isolated though component parts of a whole which the student must construct. Despite his London training, Sparks conforms to this pattern. He presumes a school knowledge of the subject—the ordinary groundwork of the processes of physical geography, that is—and so feels justified in plunging straight into a critique of the Davisian cycle. The American physiographer, W. M. Davis, is rightly regarded as the father of geomorphology and, as Sparks says, what is remarkable is not so much that some of his concepts are now questioned, but that so much of what he wrote in the 'nineties has stood the test of time.

Later chapters take up, in order, weathering, the development of slopes, the nature of a river valley, the development of drainage systems, the effects of rocks on relief, coastal features, movement of base level, the importance of changes of climate, desert and savanna land forms, land forms of glaciation, erosion surfaces and their interpretation. As these chapter headings suggest, the book tends rather to be a series of essays on the controversial aspects of the subject. By contrast, Wooldridge and Morgan is more systematic and emphasises more fully the links with structural geology.

In the current development of most sciences, and geomorphology is no exception, there are two schools of thought. One tends to build up a more or less elaborate terminology, seeking thereby to secure precision in description, if at the same time rendering comprehension difficult to the uninitiated; the other tends to deprecate the use of 'jargon'. SPARKS states that he has tried to avoid 'jargon' and in certain parts the result is unfortunate, especially in the short section on Karst phenomena, where doline, sotch, creux, sinkhole, swallow hole, swallet are all described as funnel-shaped depressions with a hole at the centre. Successive Commissions set up by the International Geographical Union have sought to bring order in the terminology of Karst phenomena, periglacial features, the evolution of slopes and correlation of terraces: unfortunately all this international work and recommendations seem to have been ignored.

These, however, are minor criticisms of a work which should be warmly welcomed as a real addition to the few books in its field, scholarly, well produced and stimulating.

L. DUDLEY STAMP.

Salt Marshes and Salt Deserts of the World. V. J. CHAPMAN. Leonard Hill, London. 95s.

After stating, in the preface, that the purpose of this book is to present a general picture of salt marshes and related tracts throughout the world, Professor Chapman goes on to make the point that in many parts of the world these marshes and deserts represent valuable agricultural or pastoral potential. This view is certainly correct, though it must be added that the extent and

type of economic development is very variable. Whatever potential for development these lands may have, however, its realisation depends to a great extent on a proper understanding of their genesis and ecology. This important book will therefore be welcomed both by students of marsh ecology and by those concerned with development of such lands. In addition to his valuable subject matter, Professor Chapman has assembled a large number of references which will greatly assist those who wish to pursue regional or other specialised aspects of the subject.

In a work whose title implies a global coverage, one notices some imbalance in the emphasis given to different parts of the world. British salt marshes get much fuller treatment than any others—as the author acknowledges. In a book of this kind one can either attempt an overall, more or less uniform, coverage; or concentrate detailed discussion on those areas where the author has special experience, referring to other regions by comparison and by reference to the work of others. The latter course, which Professor Chapman has followed, avoids the danger of wide coverage without sufficiently definitive study anywhere; and it is surely the right one to take.

The opening chapters are wide in scope and fundamental to all areas where salt marshes occur—physiology and development, tides and soils—and these lead on to detailed study of British salt marshes. In this context the use of colonisation diagrams and aerial photographs assist greatly in understanding the origin and development of the marshes.

The final preparation of this book must have coincided with the development of 'die-back' in *Spartina townsendii*—that naturally-occurring hybrid grass which, since its appearance on the coast of the English Channel at the end of the nineteenth century, has played such an important role in the colonisation of previously bare mud-flats on the south and east coasts of England. As Professor Chapman points out, this grass has considerable economic significance in reclamation work as well as in stabilisation of mud-flats, and it has been planted widely in the British Isles, in Holland, and in New Zealand. It is a pity the author was not able to round off its story by discussion of this problem, for if the plant's development carries with it the seeds of its own destruction, its economic significance may be greatly lessened. The 'disease', which seems definitely to be non-pathological, started in the area earliest colonised; its onset in one east-coast estuary can be dated as closely and recently as the summer of 1959. The incidence of die-back and an analysis of its causes have been given recently in the *Journal of Ecology* (July 1959) by workers from the University of Southampton.

It is interesting to note that die-back of *Spartina* in the British Isles is associated with development of 'rotten spots', a type of mud-pan development which Professor Chapman describes in *Spartina patensis* meadows in New England.

The penultimate chapter contains a valuable discussion on the physiology of halophytes. Research indicating that halophytes may transpire at rates not far below those of 'normal' plants shows that the early theory of 'physiological drought' in connection with salt-marsh habitats cannot always apply. Professor Chapman points out that comparatively little work has been done concerning the effect of salts, especially sodium chloride, on transpiration, respiration and seed germination—studies having been concentrated on osmotic pressures in the cell sap and on succulence. This chapter, especially when read in conjunction with the earlier one on soils, will prove valuable to those who are concerned with economic development of natural vegetation or crop plants in saline habitats.

Salt marshes are the principal subject of this book. Salt deserts, which receive comparatively little space, have been included because of their ecological affinities. Professor Chapman makes the important distinction between natural and man-made salt deserts, within which latter category, for example, must be included much of the ancient agricultural land of Mesopotamian Iraq. The process whereby irrigation leads via salinisation to abandonment of agricultural land, and hence salt desert (or even salt marsh) is still going on. Reclamation of such areas, and prevention of development of such conditions in currently irrigated or newly developed land, are presently receiving greatly increased attention. Professor Chapman touches on some of these problems in his final chapter; but their detailed discussion is perhaps anyway outside the scope of this valuable book. V. C. ROBERTSON.

Living Earth. PETER FARB. Constable, London. 21s.

One of the great weaknesses of life in our modern town-dwelling civilisation is that it insulates us from the natural world. Our powers of observation, and our interest in the wonders and beauties of creation, are educated out of us. We no longer say, with the Psalmist, 'O Lord, how wonderful are thy works; in wisdom hast thou made them all; the earth is full of thy riches'. No, we know better. To us, science, if it means atomic physics, is a menace and a mystery; but if it is biological science, the study of living creatures, it is slightly vulgar and almost certainly boring. I felt almost desperate when I read the blurb of Mr. Farb's book, with its apologetic explanation that soil was a subject for anyone to study—not only for experts. Even I, an expert, find the soil absolutely fascinating; and I am enormously pleased to discover that Mr. Farb, too, is fascinated by soil biology.

Living Earth is an extremely well written and most readable book on the great variety of living creatures, from oak-trees to wireworms and from moles to bacteria, which make their home in the soil or grow on it. The book is in five sections; an introductory one on 'the living soil', followed by three main sections on forests, grasslands and deserts, and lastly a short section on 'mutual survival'. Into this comparatively small space is packed an enormous amount of information; and yet the writing is so vivid, and the descriptions so clear, that one never gets the feeling of being crammed with facts. The stories of the kangaroo rat and how it lives in the desert, or of that insidious parasite witchweed, for instance, are brilliant pieces of scientific reporting.

But, good though this book is as an introduction to a fascinating subject, it is not an authoritative account, and, to do it justice, it is not meant to be one; the list of books for further reading shows that. It is, unfortunately, not accurate enough to be authoritative. In my own subject of soil microbiology there are several pieces of information which are out of date, or quite simply wrong (for instance, fungus cell walls are not composed of cellulose, nor is nitrate formed by reduction). On other subjects I am not an authority, and in consequence I have doubts about them. It is essential that a book which sets out to inform its readers should get its facts right, and *Living Earth* is a good enough book to be judged by the very highest standards.

I could wish that the illustrations had been a little more worthy of the text; the photographs are good but not outstanding, and in one case, that of the photograph facing page 55, the type of slime mould illustrated seems to be one of the *Acrasiales*, which is quite a different creature from the 'slime mould' referred to in the text. The drawings are decorative, but there is a kind of vagueness about them; I would be hard put to it, if I were shown the two drawings of soil profiles, to say which of them was which, or what the essential difference was between

them. The drawing of 'strange soil microbes' is strange indeed, for the four organisms are drawn at four different magnifications; the blue-green alga is magnified about 40 times, and the bacillus about 20,000 times.

These, however, are minor defects in an excellent book written by an enthusiast, and I do very much hope that *Living Earth* will really arouse interest in the soil among many readers. If it arouses more than interest, that is, if it inspires some people to undertake research on soils, so much the better. For, great though the volume of facts already known about soil may be, very many other facts remain to be discovered; and soil biology is not only a fascinating study in itself, but also, since within it lie the causes of soil fertility, perhaps the most important object of study in the world. JANE MEIKLEJOHN.

Crop Production and Environment. R. O. WHYTE. Faber and Faber, London. 63s.

Crop husbandry and plantation cropping are based on two alternative principles, namely the choice of the most suitable crops for any particular farm, or the choice of the most suitable area for production of a particular crop plant. Success or failure is largely dependent on the wisdom with which these choices are made. But population pressures are forcing more and more farmers on to areas which are not really suitable for crop production at all, and these marginal farms are likely to pose a world-wide problem.

Indeed, the crucial question whether the world can continue to feed its growing population will depend on how successful we are in increasing production from the good land already farmed, on whether marginal farms can be made to produce more reliable yields, and on the area of new land that can be brought into production.

All these developments hinge on a better understanding of the effects of weather on plants, and the completely revised edition of Whyte's *Crop Production and Environment* is published at a time when it is urgent that this rapidly growing field of knowledge should be more widely studied and understood. Dr. Whyte's long interest in the subject, and his experience with the Food and Agriculture Organisation of the United Nations, has given him a unique opportunity of studying the relations between plants and the weather, with particular reference to the introduction of new crop plants into a wide range of climatic conditions.

The book deals first with the ecological and physiological factors concerned in the effects of environment on plants, and then describes in detail the major lines of research that have been followed on a wide range of tropical, sub-tropical and temperate crops. The book is remarkably up-to-date, drawing on some four hundred papers and reviews published in the last five years, as well as giving many references to earlier basic work. A particularly interesting feature is the description of recent work in Russia that will be unfamiliar to many readers.

There is a useful summary of work on the use of chemical regulators for accelerating and retarding growth and flowering, a relatively recent development that may prove to have far-reaching new applications in crop husbandry in addition to the now familiar use of growth substances as herbicides.

Farmers will find much of interest in the sections dealing with individual crops, though they may find the earlier chapters, on effects of environment on physiology, somewhat heavy going. This is not the fault of the author, but a reflection of the present confused state of knowledge, based on a mass of experimental evidence without the unifying principles on which the results could be rationally explained. On the other hand, research workers in agronomy and related fields will find these chapters both interesting and challenging.

This new edition is a welcome addition to the sparse literature on a subject of growing importance to the world.

J. P. HUDSON.

Plants and Environment (2nd Edition). R. F. DAUBENMIRE. John Wiley, New York; Chapman & Hall, London. 56s.

Despite the similarity in title between this book and Whyte's *Crop Production and Environment*, the two books are entirely different in purpose and treatment. This book, as stated in its subtitle, is essentially a textbook of plant antecology and is more likely to appeal to the student of botany and professional ecologist than the agriculturalist or agronomist. The book, which has been considerably extended and brought up-to-date since it was first published in 1947, presents an interesting account of 'antecology', i.e., the relations between individual plants and their environment, in contrast to their 'synecology', which is concerned with the distribution of plants and their relations with other plants.

The book covers a wide field in an orderly way, but the detailed treatment given to the various aspects is somewhat uneven. For instance, the relation between plants and their water supplies tends to be somewhat over-simplified and the treatment of evapotranspiration is likely to whet the student's appetite for more information rather than satisfy his thirst for knowledge. It is surprising to find so little reference to the use of controlled environments, which are now providing ecologists with such a powerful new tool for studying the effects of environment on plant behaviour, yet there are sections dealing with new work on atmospheric pollution by smog and hydrogen fluoride, and on urban microclimate.

Nearly eight hundred references are cited, but only publications written in English were chosen ('in deference to students of intermediate status') and the absence of an author index makes it difficult to find the references which are made to any particular paper or author's work in the main text of the book. The book, which is well-produced and illustrated by photographs of some fascinating plants, should serve to stimulate interest in this field of study, especially to those working in the North American continent. J. P. HUDSON.

Reproduction in Domestic Animals. Edited by H. H. COLE and P. T. CUPPS in two volumes. Academic Press, New York and London. Vol. I $14.50 or £5 3s. 6d. Vol. II $13.0 or £4 13s.

Professor H. H. Cole and Dr. P. T. Cupps took on a difficult task when they accepted the editorship of this work, and its signal success says much for their judgement in selecting a team of distinguished writers, choosing the subjects for them to write about, and, most important of all, excluding what is already established or beyond the limit of future probability. They have cast their net wide for both subjects and authors and *Reproduction in Domestic Animals* is a welcome example of international cooperation in science. Of the 27 chapters in the present volumes, 19 are from authors in the United States, four come from Great Britain, two are from Australia, and one each from Denmark and France.

In introducing their task it was the purpose of the editors to furnish critical and integrating reviews, designed 'to bring about a fuller understanding of the complex mechanisms involved in reproduction in order to utilise such an understanding in breeding farm animals'. These avowed objectives are admirably ful-

filled in these two volumes and it is encouraging to see that those responsible for the teaching of this branch of biology in the universities are alert to its needs.

Although dealing primarily with the rapid development of our knowledge of the intricate internal mechanisms (nervous and endocrine) of reproduction and of the external factors (food and environment), which play vital roles here, these volumes are in no sense theoretical and academic, but highly practical in pointing out the application of this knowledge in animal breeding. Here the investigator will find the fundamental basis for some of the most important phenomena in reproductive physiology, with sound points of departure for the interpretation of others that are still baffling and obscure.

Following a foreword by Dr. Herbert M. Evans, Volume I opens with two short introductory chapters on the anatomy of the reproductive tract in the female and male animal, and continues with 14 separate chapters dealing broadly with the structure of the oestrous cycle and with the neurohumoral mechanisms concerned in the initiation, maintenance and termination of pregnancy. The concluding chapter of this volume includes information on udder growth and lactation. Volume II is devoted largely to a study of reproduction in the male animal but is also concerned with the nutritional and environmental factors affecting fertility and fecundity in farm livestock; the final chapters are devoted to reproduction in the domestic fowl.

Although valuable information and ideas abound in these various chapters, it seems to this reviewer that some are more outstanding than others. All are, however, extremely clear and *generally* correct, as far as they reach, and it is pleasant to see how much the authors have been able to put in so few pages.

If any remark is to be made of the reviews in general, it must of necessity be that the bibliographies include almost entirely English and American references, while foreign papers, if written in another language, are almost absent. This may not be equally true for all the reviews, but it is a great negligence to omit those many papers which have been printed in the German, French, Italian and other continental languages, since it is hardly likely that foreign scientists could have failed to contribute to all the problems under discussion in a considerably higher degree than the bibliographies seem to indicate.

For clarity, scope and interpretation of their subjects, the articles by Simpson, Catchpole and Austin are noteworthy. The weakest chapter seems to be that on libido in the male in Volume II. It is unfortunate that the author's worthy ambition has not been more successful. It is true that our knowledge of this aspect of biology is still woefully inadequate, but the chapter's value could be greatly enhanced by an attempt to bring together what is known. A really informative review on libido still remains to be written. It is unfortunate also that the author of Chapter 13 in the first volume was not more careful in his citation of the sources of the illustrations on which his figures, 5, 6 and 7 are based. The general usefulness of this chapter, already great, would be still further enhanced by a decision to use the original photomicrographs.

Nevertheless, in conclusion, it must be said that though these reviews necessarily must be limited in scope and coverage, they are authoritative and clear, and likely to be of great assistance in adding to the knowledge of students and widening the interests of scientists in this field—one of the most difficult, yet fascinating in biology. The two volumes should not only be placed in all biological institutional libraries, but should also be found on the shelves of individual biologists, for here are outlined or implied many significant problems that clamour for solution.

E. C. Amoroso.

Beekeeping in the Tropics. F. G. Smith. Longmans, London. 45s.

Dr. Smith has experience of commercial beekeeping in Europe and Africa. He was appointed to Tanganyika in 1949 to study African beekeeping and determine how beeswax and honey production could be improved and stimulated. Consequently he is exceptionally well equipped to write this first comprehensive book on tropical beekeeping, in which he lays particular emphasis on the practical and economic aspects.

While the Italian race of *Apis mellifera* is commercially well established in temperate climates and in tropical America, the natural predators in tropical Africa have so far precluded its successful introduction. The indigenous *adansoni* race, however, can be managed in hives and is reasonably productive. The European reader will find that most of the diseases with which he is familiar are rare or unreported in Africa, although the foul brood diseases are certainly capable of developing here. Pests, however, are numerous and destructive: beetles, moths and ants invade weak colonies, while the honey badger can smash wooden hives and eat the comb without being worried by stings.

In order to minimise pest attack the native hives which are made from hollow logs or bark, are hung in trees. The modern frame hives, however, cannot be managed in this way and the vicious nature of the bees makes manipulation in the open dangerous. The author has developed a system of keeping hives in beehouses to overcome these difficulties. The hives are in total shade and are cool, protected from pests and are at a convenient height for working, while 20-50 are accommodated in a single house for greater efficiency. The modified Dadant hive has been chosen as the most suitable frame hive for commercial purposes, yet there is still a place for a large capacity simple hive of low cost such as the Pettigrew skep.

Before trying to establish an industry it is essential to choose those places where the local flora is capable of supporting bees, and consequently a knowledge of the sources of nectar and pollen is required. Dr. Smith describes the various vegetation types throughout the tropics and the nectar and pollen producing plants contained in them. This field is one of the author's specialities and one of the most valuable chapters in the book. Next, the financial returns of primitive hive beekeeping, part-time frame hive beekeeping and full-time beekeeping in Tanganyika are compared. The author shows convincingly that, to make a change from primitive to frame hives profitable, an increase in surplus from 30lb. to 120lb. of honey per colony is required, as the selling price of honey is low.

In the section on bee management both primitive and frame hive manipulations are described throughout the seasons of dearth, build-up, honeyflow and harvest. The use of bees for pollination is discussed and those crops which benefit from the visits of insects are listed. Emphasis is laid on bee breeding, and the author points out that every beekeeper should aim to improve his stock by breeding from colonies showing the most desirable features. The methods of queen rearing and techniques of queen introduction enable the whole process of successful requeening to be followed.

Beekeeping in the Tropics is a reference and guide book to practical beekeeping in tropical regions. All references are listed in the bibliography and the relevant ones after each chapter. The index, paragraph headings and page headings enable information to be located rapidly. There are 69 excellent plates (mostly black and white), many diagrams, and clear constructional details.

B. S. Bowers.

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Published by Shell International Chemical Company Limited, St. Helen's Court, Great St. Helen's, London, E.C.3.
Printed by W. R. Royle & Son Limited, 207/229 Essex Road, London, N.1.